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CHILD DEVELOPMENT

Editorial Board

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DIRECTIONS FOR MEASURES AND RADIOGRAPHS USED IN PREDICTING HEIGHT

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Some need has been indicated for a set of practical directions for the measures and radiographs which are used in predicting further growth.[1] The directions given below for radiography are for use with the Todd X-Ray Standards of hand and knee for assessing skeletal age. Height is more accurately measured when the subject stands up against a rigid upright (see Figure 1) than when standing free, as when measured by the anthropometer. An accurately calibrated scale fastened to a wall is best, but lacking that, the method described here will suffice. We have included weight, because it is generally desired in any physical examination. We have not included any additional measures, as they require special anthropometric instruments and training in their use.

DIRECTIONS FOR TAKING MEASURES

Measures should be taken either naked or in light underclothing, without shoes. Note time of day at which measures are made. It is important to record the date of child's birth as well as date of taking the measures.

WEIGHT should be recorded to the nearest unit marked on the scale, for instance: 40.3 lbs., or 48½ lbs., or 32.5 kg.

HEIGHT: Have the child stand "tall" with his back against a flat wall, preferably one without a base board. Heels and back should be touching the wall. The head should be held in such a way that the lower edge of the bony orbit (eye socket) and the upper edge of the earhole are on a horizontal line. To record the height, bring a right angled object, such as a large cigar box, down the wall until it touches firmly but with light pressure against the top of the child's head. If the measure is taken against a calibrated scale, read height at the level of the top of the head. If not, mark the level of the bottom of the box on the wall. Then measure up from the floor, using a metal tape or wooden yardstick, again recording to the nearest unit marked on the scale.

TECHNIQUE OF RADIOGRAPHY

Recommended techniques for hand and knee films are presented for younger and older children. Where apparatus does not permit the short

[1]Nancy Bayley, Tables for predicting adult height from skeletal age and present height. J. Pediat., 1946, 28, 49-64.

exposures recommended, the other factors can be adapted to the convenient speed. Other adjustments may also be required according to the thickness of the part or to any variation of film. Since fine details of the diaphysi-epiphyseal plane can be obscured by differences in relative position of the central ray, attention to centering is important.

LEFT HAND: Palm down, hand flat on the film with fingers slightly separated, and the axis of the hand, wrist, and forearm in a straight line. Center the tube half way between the tips of the fingers and distal end of radius. The radiograph should include the complete fingers and at least 1½ inches

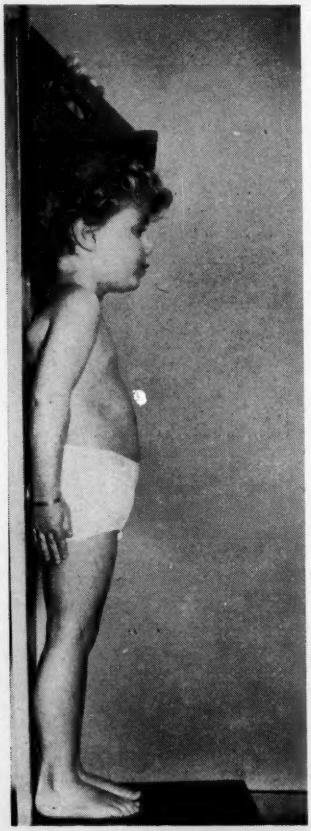

Figure 1. Correct position and method of measuring height.

of the radius, since all the hand epiphyses as well as those of the distal end of the arm are very important in the skeletal age reading.

For young children (up to the 6th birthday): distance 36 inches, screen, time 1/40 second, 150MA, 38-48KV.

For older children (past the 6th birthday): distance 36 inches, no screen, time 1 second, 100MA, 45-50KV.

LEFT KNEE

Antero-posterior view: The subject lies face down on the X-ray table with film and tube centered at the lower edge of the patella. The foot should hang over the table edge so that the knee joint is completely extended.

Lateral view: The subject lies on his left side with the lateral surface of the slightly flexed knee against the film. The right leg should be crossed over the left, resting on the table, and out of the way. Tube and film should be centered at the joint, which is on a line with the lower edge of the patella.

For young children (up to the 6th birthday): Distance 36 inches, screen, 1/40 second, 150MA, 45-50KV.

For older children (past the 6th birthday): Distance 36 inches, no screen, 5 seconds, 100MA, 55-60KV. according to thickness.

FINGER PAINTING: THE DEVELOPMENTAL ASPECTS

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and

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The widespread use of finger painting is perhaps the best indication of its value as a medium of expression. Since Shaw's introduction of finger painting in 1931 this technique has been increasingly applied to the fields of education, occupational therapy, psychotherapy and personality diagnosis.

Like many of the reported studies of children's art productions, investigations of finger painting have been conducted with emphasis on form and content of the drawings of children suffering from behavior disturbances to contribute to the diagnosis of personality.

The present study[1] was designed to show something about development as indicated by the approach of the average child to finger painting. Some of the questions considered are: How do children use finger paints in terms of the colors they select and the movements they employ? What is the finished product when viewed from the standpoint of form and content? Are there similarities or differences among age groups?

The children in this study were in a first and sixth grade in a New York City public school. There were 24 first grade children, 9 boys and 15 girls, and 29 sixth grade children, 12 boys and 17 girls. The first graders ranged in age from 5-7 to 7-4, with a median chronological age of 6-1. The sixth grade children ranged in age from 10-5 to 12-8, with a median chronological age of 11-1. The mean level of intelligence for the total school population is at the upper end of the average range. The median intelligence quotient as obtained from the school records for the sixth graders used in the study is 117. Intelligence quotients for the first graders were not available because the data for the study were collected in the fall and the policy of the school discourages early testing in the first school year.

The experiment was set up in a way that permitted opportunity for careful observation of each child in a uniform situation. It was believed advisable that each child be given the same stimulus so that the response to the situation could be evaluated objectively. There were two co-workers for the study. Each worker observed the behavior of one of two children from the

[1]The writers wish to express their appreciation to Professor Percival M. Symonds for his valuable suggestions; to Mrs. Gertrude Talley, Assistant Principal at P.S. 165, Manhattan, for her cooperation in making it possible to collect the data under most favorable conditions; and to Miss Ruth F. Shaw for her interest and encouragement.

same age group who were called to the improvised studio to paint at the same time. This experimental arrangement expedited the collecting of the data, but was primarily intended to give the children confidence in that a peer was participating in a like experience.

Two boards for painting were set on large adjustable drafting tables placed end to end. A cardboard screen was put between the tables to avoid the possibility of one child influencing the work of the other. Each board held a set of Shaw's finger paints which consists of six jars of color: red, blue, brown, green, yellow, and black. These jars were arranged in random order. A small bowl of water and a cloth were provided for each child. The two observers sat on the side to note the behavior of the children. The observations were recorded in one-minute intervals. The following explanatory comments, demonstration, and directions concerning finger painting were given to all children:

"Have you ever done finger painting? It's lots of fun. One nice thing about finger painting is that we can paint pictures with our fingers and our hands and even with our arms. And, of course, every picture tells a story.

"Another nice thing about the paints we use is that they are so safe. If some of the paint should get into our mouth, it wouldn't make us ill, and if the paint should get on our clothes, it could easily be washed out.

"Now, first I am going to show you how we get ready. Then I am going to make a picture and when I have finished I shall give you some paper and you may paint a picture too. You may paint whatever picture you like. The paper on which we paint has a dull side and a shiny side and we paint on the shiny side of the paper. We put our name on the dull side which is going to be the back.

"Now, we wet the paper. Wetting the paper will help the paints to move around more easily. Then we hold the paper this way so that the extra water will run off.

"And now, making sure that the shiny side is on the top and the side with our name on the bottom, we spread the paper on the board. We try to take out all the bubbles made by the water and all the little wrinkles so that the paper will be nice and smooth.

"Now, I am ready to paint. I think that I should like to start my picture with the green paint. We use these little wooden spoons to put the paint on the paper. There is a spoon for each color and we take this much on the spoon. You see, it is just about as much as the spoon can hold. Using our hands, we smooth and spread the paint over the paper. If it gets too dry, we add a little water to our paint this way, and this is one way we can smooth the paint. Now I think I should like to add a little black, and I shall smooth that too. See, we can make all sorts of things. These could be flowers. Now I am going to paint something else. Here are three fish resting on the bottom of the sea. And here are some smaller fish. Here are

their eyes, their fins, and their tails. They seem to be swimming in search of food. Perhaps they'll find something to eat among these sea greens. Up here, floating quietly along is a beautiful star fish and near him are some jelly fish which are called Portuguese man-of-war. They are reaching down into the deep water. And up here is another star fish. This one seems to be a baby.

"Now then, I think I have finished my story, but I want to give it a name. I know! I shall call my picture 'Our under-water friends.' Now I am going to take my picture off the board and make room for you to paint. I shall put my picture here on this paper to dry. Let's tie this apron on you just so that you won't get too wet. Now then, I think you are ready to begin!"

After the demonstration and directions were given, the children were completely free to approach the painting in whatever way they wished. No further direction or advice was given once the children started to paint.

Color

Color was analyzed in terms of 1) the first color chosen, 2) the frequency with which each color was used during the painting period, and 3) the total number of colors used. These factors were considered from the standpoint of sex and age group differences. Table 1 gives the percentage of children selecting each color as first choice.[2]

Table 1
Percentage of Children Selecting
Each Color as First Choice

	Green	*Black*	*Blue*	*Brown*	*Yellow*	*Red*
First grade						
Boys	33	0	22	0	22	22
Girls	40	0	20	0	13	27
Sixth grade						
Boys	58	0	8	0	8	25
Girls	29	0	47	12	12	0

Although the above findings are derived from a small number of cases, the indicated first choices seem to be in fair agreement with color preferences reported in other investigations. It may be pointed out that these studies, while wider in scope than the present study, nevertheless report findings which are at some variance with each other.

Winch (8), in a study of color preferences of 2000 English school children found that girls preferred blue and red in the order named, while boys preferred red and blue. Winch found that yellow decreased in popularity

[2]First choice is here defined as the first color which the child selects and with which he starts to paint.

as the children increased in age while green becomes more attractive as children increase in age. Winch indicates that the increased preference for green appears to be influenced largely by the children's mental development. He reports that children of superior development appear to favor green when they are from 12 to 14 years old. However, green generally does not rise higher than third place.

Reavis (6) studied color interests in primary and intermediate grades and found that red was a first choice among children in Grades I through IV and blue their second choice. Blue was the preferred first choice in Grade V.

Garth (2), studying the color preferences of 1000 white school children, found that 498 boys preferred blue, red, green, violet, orange, yellow and white in the order named. Red was preferred to blue in the first grade, while blue took first place in all other grades.

Table 1 indicates that in the present study green was found to be the most common first choice of the first graders, both boys and girls and sixth grade boys, but blue and red held relatively high positions for children in both grades. The sixth grade girls preferred blue, with green next in frequency as first choice.

Green and black were the two colors used in painting the demonstration picture. Consequently, the question is raised whether the factor of imitation entered into the children's preference for green. While no child used black as first choice, the popularity of green as first choice in the present study suggests the possibility that there was a tendency to imitate the demonstration in the matter of color selection. However, it is believed green would not have been chosen if it had not been pleasing to the children.

In line with Winch's findings, in the present study there is a decrease from the first to the sixth grade in the percentage of children using yellow as a first choice.

A glance at the table shows that sixth grade girls were the only group to select brown at all as a first choice. The reported studies did not include brown in their scale of colors.

The unpopularity of black in the present study is substantiated by the findings of other investigators. Winch, for example, found that black was always "hopelessly at the bottom" in the scale of preferred colors.

Most previous investigations have been rather direct in their search for color preferences in that they have requested children to indicate their preferred color and have permitted only a single response on the part of the child to each color in the color group used. The present study has assumed that the child's first choice is the color he prefers above the five other available colors.

Another basis for indication of color preference might be the frequency with which children use particular colors during the painting period. In

the present study, the colors remained at the subject's disposal for the time he painted.

A tabulation of the number of times color was taken from the jars indicates that on the average first grade boys took color 11 times while sixth grade boys took color 9 times. First grade girls took color 11 times and sixth grade girls 10 times. These results indicate little variation in age and sex groups.

When percentages were calculated to represent the proportion of the time each color was used during the painting period, the results were as follows:

TABLE 2
PERCENTAGES INDICATING FREQUENCY OF USE OF EACH COLOR

	Green	*Black*	*Blue*	*Brown*	*Yellow*	*Red*
First grade						
Boys	17	16	15	17	15	22
Girls	25	15	23	8	13	17
Sixth grade						
Boys	22	19	13	9	21	17
Girls	21	11	25	14	16	13

When color preference was based on the use of color during the entire painting period, it was found that all 6 colors were used, although not by all children. A comparison of the two approaches to color preference—first choice and frequency of use during the painting period—indicated that there is little change in the rank order of the colors. A detailed comparison of the results indicates: 1) the girls seem to be more consistent than the boys since there was little change in the rank order of the colors; 2) green remained the most popular color for first grade girls and sixth grade boys, and blue was again most frequently chosen by sixth grade girls; 3) yellow which decreased in use from first to sixth grade when first choice was regarded as the preferred color, increased in popularity from first to sixth grade when preference was based on total use of the color during the painting period; and 4) black and brown which were excluded as a first choice, with the one exception, sixth grade girls, were used by all groups during the painting period, and held positions ranging from second to sixth place. The acceptance of brown and black by an average group of children when the colors remain available to them indicates the modifiability of interpretations derived from children's use of certain colors.

Table 3 indicates the percentage of children using one to six colors:

It is to be noted that first graders, both boys and girls used all 6 colors more frequently than either sixth grade boys or girls. Only one boy in the sixth grade used all 6 colors as compared with 8 boys in the first grade. With one exception, all the children used two or more colors.

TABLE 3
PERCENTAGE OF CHILDREN USING ONE TO SIX COLORS

	Sixth Grade		*First Grade*	
	Girls	*Boys*	*Girls*	*Boys*
Six colors	18	8	20	89
Five colors	24	42	33	0
Four colors	12	17	20	0
Three colors	24	17	20	0
Two colors	18	17	7	11
One color	6	0	0	0

MOVEMENT

In the consideration of movement, an attempt was made to differentiate the finger painting motions used by the children and to indicate the particular part of hand or arm employed to execute these movements. The descriptive terms given to the various types of movements are, for the most part, self-explanatory since they are familiar verbs which in the present study have retained their popular dictionary definition.

The children's finger painting movements were observed to be of six types: Pressing, rubbing, scratching, dotting, stroking, and drawing. Each type of movement will be defined and briefly explained in terms of its use in the present study.

1. *Pressing* means "to bear upon; to make smooth; we press substances with hands, fingers or arms." As the dictionary definition indicates, the paints were pressed in order to smooth them. In finger painting, the pressing was largely a preparatory movement to painting.

2. *Rubbing* means "to spread a substance thinly over; to subject (a body) to the action of something moving, especially back and forth over its surface with pressure and friction." In the present study, rubbing motions took back and forth, up and down and circular direction. The rubbing movements varied considerably in amplitude and intensity. This variation was noted when observing individual children as well as when comparing children within the group.

3. *Drawing* means "to cause to move continuously by force applied in advance of the thing moved; to produce by or as if by tracing a pen or other instrument of delineation over a surface." In finger painting there appeared to be two kinds of drawing movements: undirected and controlled or directed movements. Although both these types of motion generally resulted in some representation, it seemed that the children used directed motion when they had some preconceived idea of what they wished to paint.

4. *Stroking* is defined as follows: "To affect in some way, especially to smooth by rubbing gently in one direction." The prominent feature of this

motion in finger painting was the short gentle upward stroke.

5. *Dotting* is defined as follows: "To mark with dots or small spots; (colloq.) to progress jerkily." In finger painting the children dotted by using the pads of the tips of their fingers to make short spring-like strokes.

6. *Scratching* means "to rub and tear or mark the surface of with something sharp or ragged." Scratching was necessarily a vigorous movement employing the fingernails to mark the painted paper.

Napoli (5), in his study "Finger-Painting and Personality Diagnosis," refers to the rhythm involved in finger-painting. He describes the rhythm in finger-painting as the ability to repeat the definite motion in a certain time pattern. Napoli indicates that the motion may be singular or in groups separated by a block of time which is the receding part of the rhythm or the pause. The pause is equally as important as the motion. "Typical rhythms in finger-painting are characterized as in music, i.e., 2/4, 3/4, 4/4, 6/8, and in addition a 5/4 and 7/4 rhythm." In the present study, it was noted that of the 6 types of movement described, rubbing, dotting, and stroking tended to be the most rhythmical.

Frequencies were tabulated for the finger painting movements. The procedure was to give each of the various motions used by a child a tally of one. In the tallying, change of movement was defined as a change from one kind of finger painting motion to another, shift from use of one particular part of the hand to another, or a combination of both these changes. For example, "rubbing with hand" received one tally; a change to "rubbing with two fingers" received another tally. "Rubbing with hand" changed to "pressing with hand" had a value of one tally for each of these two finger painting motions. Again, if there was "rubbing with index finger," and then a change to "drawing with index finger," each type of movement received a tally. A particular finger painting motion was considered to have terminated for the time being when the child interrupted his painting to take paint, or water, or perhaps clean his hands. The particular motion with which the child resumed his finger painting was given a tally even though the motion might in all ways be the motion used directly before the interruption.

Table 3 gives the percentages of children using the different types of finger painting movements.

An examination of the different types of finger painting movements yields the following conspicuous features: Rubbing, as indicated by the percentages representing frequencies of use, was preferred a good deal above the other types of movement. Rubbing, pressing, and drawing motions, in the order named, were most commonly used by all children. There was an increase, which was greater for girls, from first to sixth grade in percentage of stroking movements.

TABLE 3

PERCENTAGES OF CHILDREN USING THE DIFFERENT TYPES OF FINGER PAINTING MOVEMENTS

	First Grade	*Sixth Grade*
Pressing		
Boys	22	23
Girls	30	22
Rubbing		
Boys	52	47
Girls	46	42
Drawing		
Boys	15	13
Girls	18	19
Stroking		
Boys	7	11
Girls	3	12
Dotting		
Boys	2	2
Girls	1	5
Scratching		
Boys	2	2
Girls	1	1

It would seem that the popularity of rubbing motions in finger painting has developmental basis. Rubbing more than the other 5 types of finger painting motion is a convenient means for satisfying the urge for activity which is so strong in the period from 6 to 12. Jersild (3), says, "Healthy children of this age are on the go much of the time. They seem to possess almost boundless energy." The increase in stroking movements seems to be in line with increased development in motor skill that comes as children advance in age. Stroking, in this study, is characterized by gentleness of movement which calls for somewhat finer motor control than most of the other finger painting motions.

Table 4 lists the arm and parts of the hand that the children were observed to have used in their finger painting movements. The percentages indicate frequency of use.

The table shows that with the exception of first grade girls, who preferred the whole hand, the children used the index finger most frequently in their finger painting.

Percentages were computed so as to determine relationships between the different types of movement and parts of the hand used for painting. It was found that the index finger was the preferred finger for: Drawing, stroking,

TABLE 4

PERCENTAGES INDICATING THE PROPORTION OF THE MOVEMENTS IN WHICH THE ARM AND PARTS OF THE HAND WERE USED

	First Grade		*Sixth Grade*	
	Boys	*Girls*	*Boys*	*Girls*
Arm and hand	2	0	1	0
Arm alone	4	3	5	6
Both hands	16	0	2	1
Whole hand	22	38	13	13
Palm and four fingers	3	0	0	1
Palm alone	0	1	4	1
Side of open hand	2	0	2	4
Heel of hand	0	1	0	1
Five fingers	2	2	8	8
Four fingers (thumb excluded)	14	11	8	7
Second, Third, and Fourth fingers	2	6	20	10
Second and Third fingers	1	8	4	7
Thumb	0	0	1	2
Index finger	30	30	26	32
Middle finger	0	0	4	2
Fourth finger	0	0	0	1
Small finger	0	1	1	2

and dotting motions of boys and girls in both first and sixth grades, scratching motions of first grade girls and sixth grade boys and girls, and pressing motions of sixth grade girls. The index finger was second in order of frequency of use for rubbing movements of first grade girls and sixth grade boys and girls. The index finger held third position for rubbing movements of first grade boys and pressing movements of sixth grade boys. And lastly, the index finger was fourth in order of frequency of use for pressing movements of first grade boys and girls.

The data show that when the children painted with their index finger they used all six types of finger painting motions. These findings favor the index finger with greater diversity of movement than reported by Napoli (5) in his study of finger painting. Napoli recognizes eleven general types of finger painting motions and reports the use of the index finger only in "scribbling" which he describes as an isolated finger movement imitating pencil writing.

The index finger readily leads in the manipulation of materials and becomes the finger that is greatest conditioned by the use of such graphic tools as crayon and pencil. These factors have doubtlessly influenced the

present study so that the index finger was found to be the most commonly used finger for 5 of the 6 described finger painting motions. It might be mentioned that 10 of the 53 children in the present study reported that they had finger painted once or twice before. However, it was observed that, on the average, these children painted with their index finger equally as many times as the children who were having their first experience with finger painting.

Rubbing, as previously mentioned, was found to be the most commonly used finger painting motion. The data indicate that the whole hand was most frequently used for the rubbing motion by first grade children, both boys and girls, and sixth grade girls. Sixth grade boys most frequently used the second, third, and fourth fingers in combination for this movement.

A glance at the table shows that first grade boys used both hands simultaneously for painting considerably more than the other children. It is their finger painting behavior that accounts for the relatively high percentage representing frequency of use of both hands in the case of the first grade boys.

The two most evident findings that emerge from an analysis of parts of the hand used are: First, that the index finger plays a prominent role in the finger painting of all children in the study, both first and sixth grade boys and girls; and secondly, from first to sixth grade for both boys and girls, there is a decrease in the use of the whole hand for painting and in general an increase in the use of the fingers, individually and in combination. The latter finding simply gives recognition to the fact that the ability for finer manipulation and control comes with maturity.

Note was made of handedness during the painting period and it was found that of the 53 children in the study, 38 children used their right hand exclusively for painting. The other 15 children were observed to be ambidextrous. In this group of 15, there were 6 first grade boys and 3 first grade girls. Two boys and one girl were reported left-handed. In the sixth grade, 3 boys and 3 girls used right and left hands interchangeably. One sixth grade girl reported that she was left-handed. In the first grade, 25 per cent of the right-handed children alternated in the use of the hands, while in the sixth grade 17 per cent of the right-handed children used right and left hands interchangeably. The percentages for right-handed boys and girls using both right and left hands were 17 per cent and 8 per cent respectively in the first grade, and 10 per cent and 7 per cent respectively in the sixth grade. If the theory that handedness results from conditioning is here accepted, then the decrease in ambidexterity from first to sixth grade might be explained in terms of time which more firmly establishes right-handed response. It should be mentioned that while this group of 15 children alternated in use of the hands, they most frequently used the dominant hand for their finger painting.

Form

In the consideration of the formal qualities of the children's finger painting it was found that the finger painting activities could be divided, for the most part, into two categories—preparation and representation.

Preparation involved steps preliminary to representation and included elements such as: position of paper on the board—whether the child placed the paper horizontally or vertically—on what part of the paper he put his first daub of paint, the texture or the degree to which the paint had been worked and smoothed on the paper, and the extent of the surface covered with paint. Data concerning the steps preparatory to representation indicate that all the children placed the paper in a horizontal position on the board and all but one child stood at the end of the table directly in front of the paper. The one exception was a sixth grade Mexican boy who placed his paper the same as the other children's, but stood at the side of the table which consequently gave his paper vertical position. The children's almost complete agreement in regard to horizontal placement of paper was doubtless suggested, to some extent, by the administrator who placed the paper horizontally for the demonstration painting. Napoli (5), in his study of finger-painting, likewise found a definite preference among subjects for horizontal placement of paper. Napoli indicates that those who paint scenes will place the paper in a horizontal manner. As creative skill develops there is a tendency for the subject to place his paper in a vertical position.

In the present study, the one paper that was placed in vertical position holds a somewhat bold painting of the head of "Christ" and stands in sharp contrast to the rest of the children's painting which are "designs" and scenes of one sort or another.

To facilitate recording the area in which the children placed the first daub of paint, the paper was regarded as divided vertically into left, center and right areas and horizontally from the top to lower edge into first, second and third areas, so that the paper had nine divisions: left 1, 2, 3; center 1, 2, 3; and right 1, 2, 3.

The study indicates that 79 per cent of the children (70 per cent of the first graders and 86 per cent of the sixth graders) placed the first daub of paint in area center 2 of the paper. There were little sex differences. This expressed preference on the part of the children to place the first daub of paint in area center 2 might perhaps be best explained in terms of our basic need to maintain balance.

The 21 per cent of the children in the present study who did not place the first daub of paint in center 2 showed no particular preference for any other specific area.

The children's work was examined to determine any age or sex differences in relation to texture or consistency of the paint that was spread on the paper. The paintings were classified as being either lumpy or smooth.

In the first grade the larger percentage of paintings was classified as "lumpy." In the sixth grade the reverse situation was found; the larger percentage of sixth grade productions had smoothed paint. The increase from first to sixth grade in the number of paintings where the paint had been worked smooth was greater for the girls (33 per cent to 88 per cent) than for the boys (44 per cent to 58 per cent).

In studying the children's productions from the standpoint of extent of surface covered, it was found that the paintings could be readily differentiated into four groups:

Group I held paintings which did not extend to the ends of the paper. Although apparently without intent, the children with paintings in Group I, spread the paint carefully enough to give the uncovered part the semblance of a frame for the painting within. The unpainted borders varied from one to three inches in width and in no instance were they found to go beyond two sides of the paper.

In Group II were paintings of children who spread the paint to the edge of the paper, but failed to completely cover the outer areas. Most of the paintings in this group had small uncovered areas in the upper corners of the paper.

Group III consisted of paintings which had spaces here and there over the paper. In some of the paintings the uncovered areas were quite small, but there were other paintings where the unpainted parts were of such extent that they became background for the representation.

The paintings in Group IV were distinct in that the surface of the paper was completely covered with paint.

The following table indicates the percentage of the paintings for first and sixth grade children that were classified as belonging in each of the four groups:

TABLE 5

PERCENTAGE OF PAINTINGS CLASSIFIED ACCORDING TO EACH OF FOUR GROUPS

	First Grade		*Sixth Grade*	
	Boys	*Girls*	*Boys*	*Girls*
Group I	11	13	8	12
Group II	56	40	17	24
Group III	22	20	8	18
Group IV	11	27	17	47

The table shows that in the first grade the largest percentage of paintings were in Group II and in the sixth grade the largest percentage of paintings were classified as belonging to Group IV. These percentages indicate that over half of the children tended to completely cover the surface of the

paper. The sixth graders, however, did a more thorough job of spreading the paint than did the first graders.

Representation, as it relates to form, is concerned with the nature of the child's symbolization. In the approach to representation there was no attempt to set up criteria first by which to analyze the children's art productions. The finished paintings were studied with a view to determining sex and age similarities and differences.

The finished productions indicate that the children with paintings in Groups I, II, and IV employed the same approach in their art work. A first step with children in these three groups was to spread paint more or less automatically on the paper, apparently to have a background for the representation. The representation consisted of curved and straight lines which in the majority of cases were painted singly so as to merely outline the form of the figure. There were, however, in these three groups, several instances where whole or parts of paintings had lines in combinations so complex that the representation appeared as solid form.

The children whose paintings came into Group III omitted the preparatory step of first covering the surface of the paper with a mass of paint which could serve as background. Instead they began directly with representation.

Differences in approach made readily discernible differences in the formal aspects of the paintings. In contrast to the "line" symbolization which in the main characterized the productions in Groups I, II, and IV, the paintings in Group III consisted of solid areas of pure color placed one adjacent to the other. It seems that because in this group of paintings there was no background on which the representation might rest, the children gave stability to the representation itself.

It was found that the children used the colors in either pure or blended form. There were, however, two types of blending: one which, in most instances, indicated control over the medium used; the other, a more or less haphazard application of colors which gave a muddy effect.

There was a decrease in the use of pure color from first to sixth grade for both boys (33 per cent to 17 per cent) and girls (27 per cent to 18 per cent) and an increase in colorful blending for both boys (22 per cent to 58 per cent) and girls (40 per cent to 71 per cent).

There was also a decrease from first to sixth grade for boys (44 per cent to 25 per cent) and girls (33 per cent to 12 per cent) in blending that resulted in muddy color.

The three factors—the extent to which the surface of the paper was covered with paint, the degree to which the paint was smoothed, and the blending of the colors—indicated improvement with age and were considered by the experimenters as criteria by which to differentiate the children's paintings into first and sixth grade groups. It was found that the actual symbolization was in most instances characterized by an immature

simplicity which made the paintings appear strikingly alike. Finger painting was a comparatively new experience for 10 of the children in the study. For the rest of the children, finger painting was a wholly new experience. The immature elements in the paintings can be related doubtlessly to the unfamiliarity of the situation. Confronted with a strange tool, the children tended to regress to earlier habits of representation.

It has been generally recognized that there is a tendency for the young child to display immaturities in his mode of expression when he meets a new situation. Biber (1), in her study of the development of drawing in young children, indicates that a new situation for the four-year-old is using crayons to make not a drawing but a picture. As a consequence of the new situation, some of the pictures of the four-year-olds show a repetitive tendency associated with the early pre-representative stages. The radiating lines, with circles at their ends, probably representative of fingers, are repeated, and these lines start at what would correspond to the ear level. Biber questions, "Are these repeated lines with circles an evidence of his ignorance or are they a regression to his earlier habit of repetition, called out by the strangeness of the situation?"

Figures 1 and 2 are examples of the points discussed in reference to area covered, texture, blending of colors and nature of representation of a first and sixth grader respectively.

The present study indicates that in initial experience with finger painting, children may tend to use earlier developed means of representation. However, repeated experience with this medium encourages facility of expression and productions which are truly things of beauty, as workers in this field can indicate.

In the present study, two judges were invited to classify the children's finished work. Both judges had considerable experience in the field of art. In attempting to divide the children's paintings into first and sixth grade groups, the judges drew from commonly adopted criteria for measuring progress which consists of factors such as increase in detail, correct placement of detail and improvement in proportion and perspective. Both judges indicated difficulty in using these criteria to separate first and sixth grade paintings.

Judge A, an artist of repute, correctly classified 68 per cent of the paintings. Of the total number of paintings, 15 per cent were judged to be the work of sixth grade children and actually belonged to the first graders. Seventeen per cent of the total number of paintings were incorrectly classified as first grade paintings.

Judge B, an expert in the field of finger painting, correctly classified 62 per cent of the paintings. Of the total number of paintings, 21 per cent were judged to be the work of the sixth grade children and belonged to children of the first grade. Seventeen per cent of the total number of paintings were incorrectly classified as having been done by first grade children.

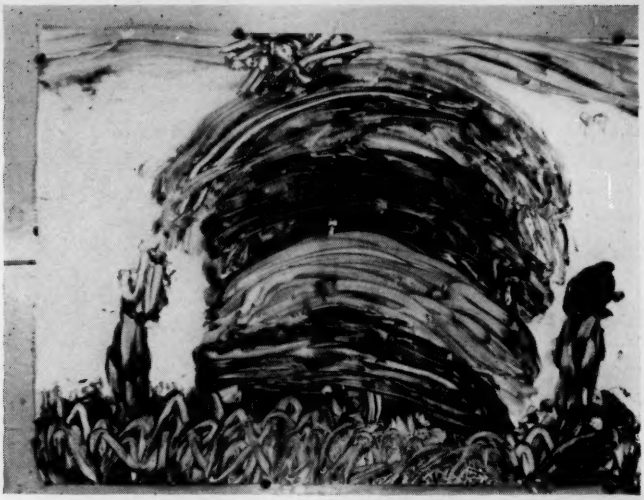

Figure 1. First grade painting.

Content

The final consideration was the content of the children's paintings. Content was approached from the standpoint of both the titles which the children gave to their paintings and the objects actually depicted.

When the children finished they were asked to give their painting a name. Titles were classified as either having general concepts (e.g. Harvest Time, Autumn Days, Flower Time), or as pertaining to the specific (e.g. The House in the Woods, The Tree on the Hill, The Snake in the Water). The trend in concept development was evident in that 31 per cent of the titles given to their pictures by sixth graders could be regarded as dealing with general concepts, whereas only 17 per cent of first grade titles could be so classified.

In an indirect approach to children's thought processes by asking children from the ages of 5 to 12 to express their wishes, Jersild, Markey and Jersild (4) found that "the older the child, the more likely he is to express his wish in general and inclusive terms, rather than in terms of limited concrete objects." Other studies likewise indicate a gradual increase with age from specific facts to general terms and concepts.

An analysis of the representations showed that all in all, 35 different objects were painted. The first graders had 19 different representations as compared to 25 by sixth grade children. There was no substantial age or sex difference in the average number of objects depicted.

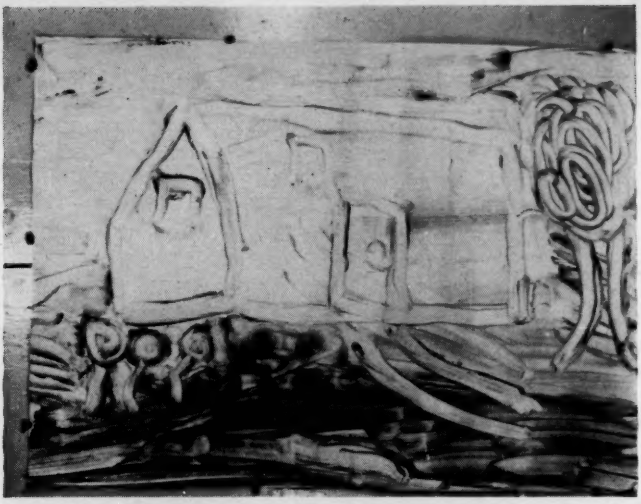

Figure 2. Sixth grade painting.

The most popular representations among the first grade boys were fish (33 per cent) and water (33 per cent) which may have been a tendency to imitate the demonstration picture. Next in order, and equally popular (22 per cent) among themselves were men, sun, sky, houses, earth, flowers and algae. First grade girls most frequently painted flowers (58 per cent) with sky (42 per cent) and earth (42 per cent) next in order of frequency.

In the sixth grade, both boys and girls most frequently included earth (boys, 50 per cent; girls, 47 per cent) with flowers and sky next (boys, 33 per cent; girls 41 per cent) most frequently painted. The children's paintings also included representations such as rainbows, trees, mountains, men, jungles and animals.

Summary

The purpose of this investigation was to study finger painting in terms of developmental processes and under a standard set of conditions. The subjects were drawn from a first and sixth grade of a public school where the average intelligence level falls in the group usually classified as being high average. There were 9 boys and 15 girls in the first grade and 12 boys and 17 girls in the sixth grade. Sex as well as age differences were considered.

Though they cannot be considered conclusive due to the small number of subjects, the results indicate certain developmental trends which are consistent with the findings of research in the areas of color preference, movement, representation, and concept formation. When color preference was studied from the standpoint of first color chosen and the frequency with

which the colors were used in the painting period, the results were in agreement. The exception was in the case of first grade boys who chose green in one case and red in the other. Green was consistently the most popular choice for first grade girls and for sixth grade boys. Sixth grade girls preferred blue in both cases. All groups used all colors some time during the painting period and there was no difference in relation to age or sex in the amount of paint used as estimated by the number of times children took paint from the jars.

The results of the analysis of the movements used and parts of the hand and arm employed in finger painting also indicate certain recognized developmental trends. In general, rubbing, pressing and drawing motions, in the order named, were most commonly used by all children. However, the development of finer motor control with age is evidenced by the increase in the use of stroking movements by the sixth graders. With the exception of first grade girls, the children used their index finger more frequently than any other part of the hand or arm; the first grade girls used the whole hand most frequently. Further evidence of the expected developmental trend from gross to finer motor activity is evidenced by the fact that there is a decrease in the use of the whole hand for painting and in general an increase in the use of fingers, individually and in combination.

In representation, the three factors—the extent to which the surface of the paper was covered with paint, the degree to which the paint was smoothed and the blending of the colors—indicated improvement from first to sixth grade for both sexes. The paintings could be differentiated into two types: those which had a background and representation which was for the most part in outline form, and paintings which had no background and consisted of solid areas of pure color placed one adjacent to the other. The majority of the paintings were classified as belonging in the first described group.

All the paintings were characterized by immature elements which made them appear strikingly alike. Two judges indicated difficulty in differentiating between first and sixth graders on the basis of accepted criteria for measuring progress in children's art work. Regression to earlier modes of expression is doubtless related to finger painting being a new media for most of the children in the study.

The trend in concept development was evidenced by the fact that there was an increase from the first to the sixth grade in the number of titles dealing with general terms rather than specifics. Analysis of the representations showed that there were 35 different objects painted with no substantial age or sex differences in the average number of objects depicted. The most popular representations were: first grade boys—fish and water; first grade girls—flowers, sky, and earth; sixth grade boys and girls—earth, flowers, and sky.

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SERIAL STUDIES OF CHANGES IN DIMENSIONS OF THE DENTAL ARCHES FROM BIRTH TO NINE YEARS*

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The orthodontist's main interest is the prevention and correction of the defects of occlusion of the dental arches. Therapy consists of directing and producing changes of these defects so as to obtain a more favorable occlusion. There has been an increasing awareness that the problem of orthodontics is a part of the general problem of maturation, especially as it relates to the face and the dental arches. Many important studies have been made of the face, some longitudinal. Studies of the dental arches, however, have not been as extensive. Most of these studies are cross-sectional, and were started at two years of age or later. This paper presents a longitudinal study of dimensional changes in the dental arches of a group of 38 children from birth to 9 years.

All are normal, white, and come from varied economic levels. At present 14 are 3 to 7 years old, and 24 are 8 and 9 years. Individual impressions of the maxillary and mandibular arches were taken periodically, from which casts were made and measurements taken. The number of casts for each child ranges from 6 to 25 casts, the average being one set of casts per year. The total number of casts was 320.

What anatomical points can be used for measurements which we find at birth that persist through life? At birth there are many landmarks, but with time most of them become obliterated. However, the lateral salcus, which also defines the inter-dental papilla, is clearly marked, and is located between the deciduous canine and the first deciduous molar. The crests of these papillae were the points from which the width of the maxillary and mandibular arches were measured. This was the only measurement I found that could be used with reasonable accuracy.

In order to study this dimension as it relates to occlusion, I have divided my group into good and poor occlusion as found in the latest casts. Good occlusion refers to a regular arrangement of teeth within the dental arch,

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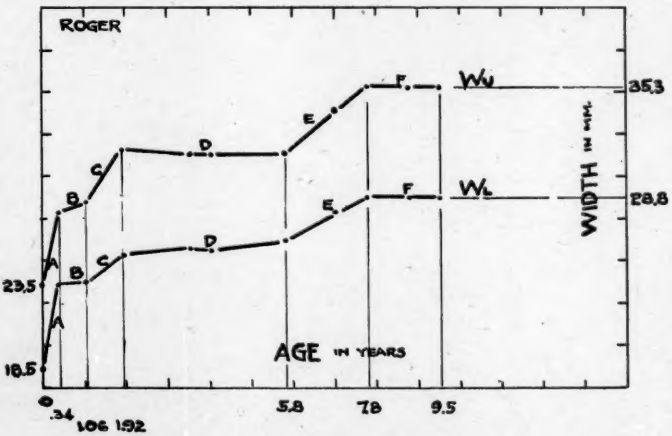
The author wishes to thank Dr. Leo Winter, Dr. L. E. Holt, and Dr. W. E. Studdiford in whose departments at Bellevue Hospital part of this study was made, Dr. Harry Bakwin for his counsel, and finally the parents and children who are cooperating in this study.

and a good contact of teeth between the jaws. When there is a deviation from this arrangement other than a slight variation, I have classified it as poor occlusion.

Is there a pattern of change of width in the dental arches? Does the pattern bear any relationship to the occlusion? In order to find the answers to these questions, curves for each arch were plotted of the width (in millimeters) and age. The maxillary arch is designated by WU, and the mandibular arch by WL. Each dot indicates the measurements of casts taken at that age.

Let us examine a few individual curves. Roger has a good occlusion (Graph 1). His pattern of change is characteristic of a number of children with good occlusion. Note that there are periods of increase alternating with periods of no increase. The first increase in width (A) extends from birth to 0.34 year. This is followed by the shortest period of no increase or plateau (B) extending from 0.34 year to 1.06 years. I do not consider the



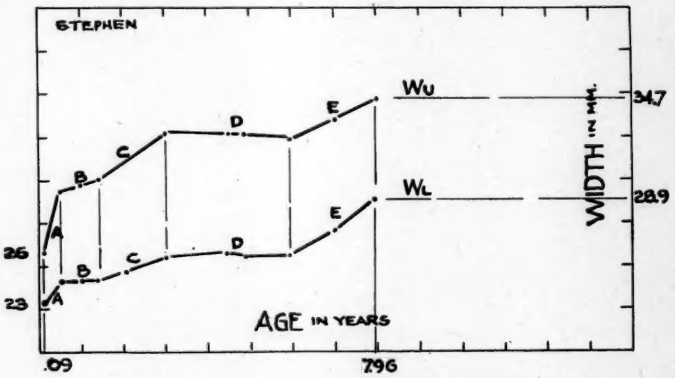
Graph 1. Roger has a good occlusion. Note the pattern of change is composed of three periods of increase alternating with three periods of no increase.

slight increase for this period and others (B, D) as significant. From 1.06 years to 1.92 years there is a second increase (C) with a rate not as great as for the first increase. The second plateau extends from 1.92 years to 5.8 years (D). There is a third increase (E) from 5.8 years to 7.8 years, with a rate that is also less than the rate of the first increase. The third plateau (F) extends to 9.5 years. In other words, Roger's pattern of change is com-

posed of three periods of increase alternating with three periods of no increase in width. The first increase has the greatest rate, while the second plateau has the longest span. The curves of both arches form a relatively parallel pattern to each other.

At birth Roger's maxillary width is 23.5 mm, and the mandibular width is 18.5 mm, or a difference of 5 mm. At 9.5 years, the maxillary width is 35.3 mm, and the mandibular width is 28.8 mm, or a difference of 6.5 mm.

Stephen also has a good occlusion (Graph 2). His curves form a pattern (A, B, C, D, E) similar to Roger's, although the onset, amount, and duration of increase, and the onset and duration of the plateau are individual.

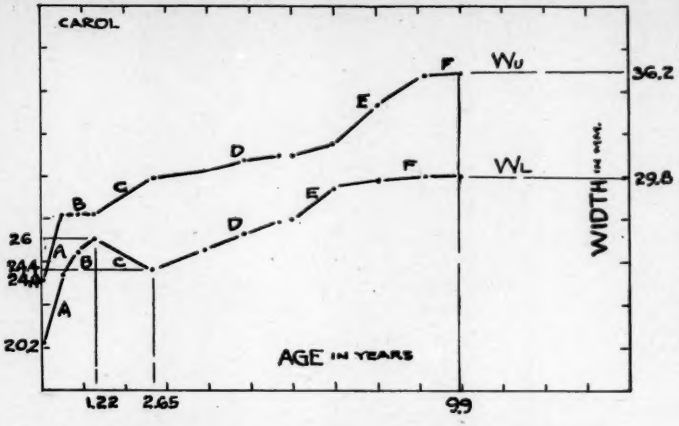


Graph 2. Stephen has a good occlusion. The pattern of change is similar to Roger's.

At 7.96 years the third plateau (F) has not appeared. At 0.09 year Stephen's maxillary width is 26 mm, and the mandibular width is 23 mm—a difference of 3mm. At 7.96 years, the maxillary width is 34.7 mm, and the mandibular width is 28.9 mm, giving a difference of 5.8 mm.

There are other variations of the patterns among the children with good occlusion. Some exhibit a rhythmic pattern of three periods of increase alternated by periods of slower rates of increase, rather than plateaus. Others show a partial expression of this rhythmic pattern, while some present a pattern of constant change.

Carol presents some interesting features (Graph 3). The maxillary curve is similar to Roger's and Stephen's, but the second plateau has a slight upward slope (D). Her mandibular curve shows a decrease of 1.6 mm in width between 1.22 years and 2.65 years. Does this suggest the onset of a defect of the arch? The decrease of dimension plus the constant varying of

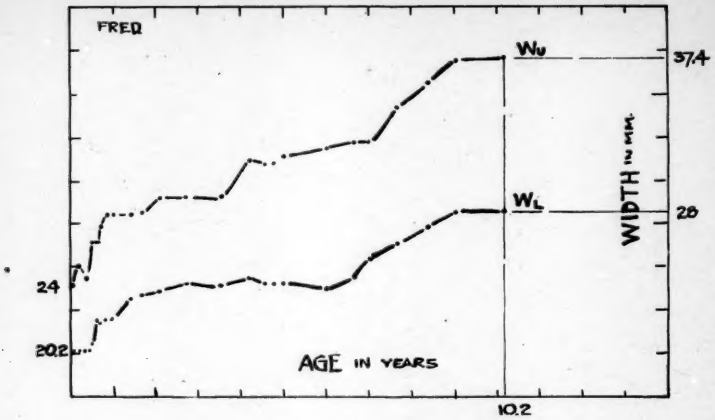


Graph 3. Carol has a good occlusion at present. Her maxillary curve is similar to Roger's and Stephen's. Note the decrease of dimension in the mandibular curve.

the dimensional differences between her two curves may foreshadow the development of poor occlusion. Although this child has good occlusion at present, her casts taken at 9.9 years suggest this change. Time will answer this question. However, the differences of dimension between the arches at birth and 9.9 years approximates Roger's and Stephen's, and are within the range of measurements associated with good occlusion.

The next graphs (4, 5, 6) are examples of poor occlusion which are associated with a greater variation of differences of dimensions between the arches. I have 25 casts of Fred since his birth (Graph 4), of which 12 were taken during his first two years. The diagnosis of poor occlusion was made clinically when he was 1.5 years. Are the irregularities of the curves occurring before this age a pre-clinical sign of future poor occlusion? Note the decrease in width at several points, and also the varying rate of change in the curves, particularly in the maxilla. His difference in the width between the arches seems to be of importance. At 0.08 year, the maxillary and mandibular widths are 24 mm and 20.2 mm respectively, or a difference of 3.8 mm. At 10.2 years, the respective widths are 37.4 mm and 28 mm, or a difference of 9.4 mm. This is the largest difference in dimensions found in the entire group, and may be another indication of poor occlusion.

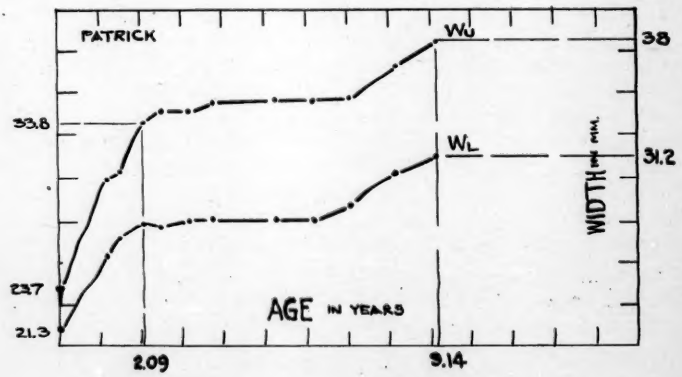
Patrick is another example of poor occlusion (Graph 5). His dimensional difference at birth is 2.4 mm, while at 9.14 years the difference is 6.8 mm. Of all the children of my group, he has the greatest increase of width in the maxilla during the first two years. At birth the maxillary width is 23.7



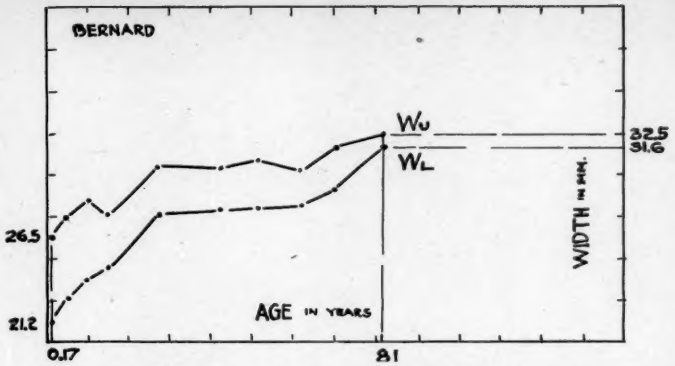
Graph 4. Fred has a poor occlusion. Note the irregularities and spread of curves.

mm, and at 2.09 years, it is 33.8 mm, or a difference of 10.1 mm. Did this large increase determine the development of his poor occlusion?

Bernard (Graph 6), the brother of Patrick (Graph 5) has a very poor occlusion. The varying dimensional differences between his maxillary and mandibular curves are of particular interest. At 0.17 year, there is a difference of dimensions of 5.3 mm, and at 8.1 years, the curves have converged



Graph 5. Patrick has a poor occlusion. Note the marked increase in the maxillary curve for the first two years.



Graph 6. Bernard has a poor occlusion. Note the irregularities and convergence of curves.

to a dimensional difference of 0.9 mm. Is this convergence of dimensions associated with the development of poor occlusion?

In considering the group as a whole in regard to the influence on occlusion of decrease in width, the following findings are of interest. Of the 16 children with good occlusion, 6 show a decrease in width. Of the 22 children with poor occlusion, 13 show a decrease in width.

The difference of dimensions between the dental arches also seems to have an influence on occlusion. At birth the range of dimensional differences between the maxillary and mandibular widths varies from 1.3 mm to 5.8 mm. There are 5 children who at birth had a difference of width less than 3 mm; 4 of them have poor occlusion to date. This suggests that the onset of poor occlusion occurred in the pre-natal stage of development. The difference of width in the last casts ranges from 0.9 mm to 9.4 mm. Five out of the 6 children in whom this difference is over 7 mm have poor occlusion. Of the four children with a dimensional difference under 4 mm, three have poor occlusion, and the fourth child suggests a change toward a poor occlusion.

Moreover, occlusion is not static. Some good occlusions may become poor, and vice versa. I believe there will be a greater increase in the number having poor occlusion, thereby increasing the significance of the association of poor occlusion with decrease in width and difference of dimensions.

These findings suggest that the pattern of change, the relative parallel relationship between the curves, decrease in width, and difference of dimensions, are important factors in determining the development of the occlusion of the teeth.

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THE ANTHROPOMETRIC APPROACH IN THE PRACTICE OF THE PEDIATRICIAN[1]

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The use of height and weight measurements as a fundamental base for the appraisal of development and physical condition is a well established practice in pediatrics. Measuring head and chest circumference is also incorporated in pediatric routine checks. The value of further anthropometric examinations for pediatric purposes, however, is a controversial matter. The main obstacles for the general acceptance of more detailed anthropometric studies are the lack of generally accepted selections of measurements, lack of adequate statistical material for the evaluation of such measurements, and the complicated character of many of the suggested examinations.

Anthropometric methods acceptable for use in pediatric practice have to be simple, should not require too much time and, if possible should not require special equipment. Still they have to be sufficient to give a representative picture of body build and developmental state. During the years 1926-1938 preliminary studies were conducted on various material in Vienna, to select measurements and to try out methods of evaluation that appeared simple enough to be used in pediatric routine checks (1-13). Based on these studies some measurements were selected and used in all routine examinations in my pediatric private practice during the last 8 years. These measurements are: Weight; body length or standing height; stem length or sitting height; circumference of head, chest, wrist, forearm, arm, calf; length of the hand and of the middle finger; and breadth of the hand. Other measurements, included in those earlier studies, were omitted in these more recent observations. Such now eliminated measurements are: Length and breadth of the head and of the face; diagonal of the head; thickness of skin folds on chest, abdomen, and back; and thickness of the subcutaneous tissue on the cheeks.

Body length was taken during the first year of life in the recumbent position, in older children in the standing position; stem length was taken during the first year of life with head and trunk in the dorsal recumbent position and with hips and knees flexed to right angles; in older children in the sitting position. The importance of the sitting height was first stressed by *Van Pirquet* who, for biologic and anatomic reasons, preferred this measurement to the whole body length for the appraisal of the nutritional condition as well as for the appraisal of food requirements. This

[1]Paper presented at meeting of the Society for Research in Child Development, Boston, December 27-28, 1946.

measurement is in practice more easily obtainable than supra and infra pubic length, and it gives, especially in combination with body length, a good picture of the main body proportions. Head circumference was measured over glabella and occipital prominence; chest circumference in a horizontal plane running above the nipples and below the inferior angle of the scapula. During the last few weeks studies were started concerning this "orthodox" chest measurement of the European anthropology in relation to the chest circumference taken at the level of the xiphoid, as is preferred in recent studies in this country. The relationship between these two measurements may contain characteristic features in different individuals. Circumference of the wrist was introduced in insurance medicine (14-16) with the idea that this measurement should be of value to characterize the individual type of skeletal structure as robust or slender. This is true for older children as well as for adolescents and adults, while in early childhood this value is diminished by the thickness of overlying soft tissue in many babies and by the occurrence of a widened epiphyseal region in cases of clinical and subclinical vitamin D deficiency. As a contrast to this wrist measurement, the circumference of the forearm, the arm, and the calf gives a representative picture of the distribution of the soft tissues in the body throughout childhood and adolescence with a possibility of analyzing the role of fat tissue on the one hand and of muscle tissue on the other. This method of analyzing the development of the different components of body structure in different individuals was used, for example, in studies concerning the effect of open air treatment in children with inactive tuberculosis and the subsequent effect after discharge from such treatment (17-21). Measurements of the hand had not been utilized in the earlier publications concerning this method of habitus analysis, but were included in these more recent studies. Hand measurements are characteristic in some extreme types of body build as seen in some pathologic conditions (arachnodactyly, hypothyreosis, chondrodystrophy, etc.) and are also characteristic for some well defined types of body build within the limits of normal variations. These measurements were taken in our preliminary studies by caliper, later with a simple ruler, preferably of a transparent plastic material. Hand length was measured from the most distal of the three complete transversal creases on the volar side of the wrist to the tip of the middle finger; length of the middle finger from the skin crease at the volar side of the basis of the middle finger.

Means were calculated for all these measurements for 2500 observations on boys and for 2100 observations on girls. More detailed statistical work has been done up to now for 100 boys and 100 girls of each of the following age groups: Newborn, 3 months, 6 months, 9 months, and 12 months; and for 100 boys and 80 girls of 18 months. Based on the statistical results, evaluation charts were constructed for these measurements and for some indices. The values of ½, 1, and 2 times the Standard Deviation (σ, Sigma)

were chosen to define the evaluation classes. In this way 9 evaluation classes were formed:

1) higher than twice the standard deviation above the mean value
2) between one and two standard deviations above the mean
3) between ½ and 1 standard deviation above the mean
4) between mean and ½ standard deviation above
5) just the mean (purely accidental—of no statistical significance)
6) between mean and ½ standard deviation below
7) between ½ and 1 standard deviation below the mean
8) between 1 and 2 standard deviations below the mean
9) lower than 2 standard deviations below the mean

Indices used are: Sitting height divided by standing height or stem index; chest circumference and hand length divided by standing height or relative chest circumference and relative hand length; hand breadth and length of the middle finger divided by hand length; and Pirquet's Pelidisi Index (the cubic root of ten times the body weight divided by sitting height), an index which was used extensively in studies concerning nutritional conditions in children in Austria, for instance, in connection with the effects of the post war depression in Vienna 1920-1930 (22). Statistics and evaluation charts for older age groups are in preparation.

Mean values and standard deviation of height, weight and some of the other measurements in my material were compared with the figures obtained by other authors in more recent publications, for instance, *Katherine Simmons* (23)—*Brush Foundation* material; *Vickers and Stuart* (24)—*Harvard Growth Studies; Meredith* (25)—*Iowa Studies; Sontag and Reynolds* (26) in publications for the *Fels Research Institute, et cetera.* It can be shown that the figures derived from my materials, although gathered under the handicap of conducting the examinations within the regular office practice, are comparable with the figures obtained under the much more accurate conditions in these studies from different parts of the country (Chart 1).

The results of such anthropometric examinations may be recorded and reported in different ways. For reports to other physicians on cases in consultation a special report sheet was used. The measurements found in the patient are recorded in centimeters and kilograms as well as in inches and pounds; comparison with average findings is made easy by 3 additional columns. The average physician, who is not familiar with anthropometric and statistic methods, has little use for a report given in terms of standard deviation or percentiles. Amount of the deviation from the average, however, may give him some idea of the characteristic features of the case. If the size of the child deviates considerably from the average for his age group, comparison of the measurements with average values for the patient's size or standing height, besides the comparison with the average for the patient's age, is indicated. Still more impressive in many cases is a com-

CHART 1

Comparison of Means and Standard Deviations for Body Length, Crown Rump Length, and Weight in our material with the values found in the studies by *Katherine Simmons* and by *Vickers* and *Stuart*.

Age	— Boys —						— Girls —					
	Means			Standard Dev.			Means			Standard Dev.		
	Kf	V S	S	Kf	V S	S	Kf	V S	S	Kf	V S	S
					Body Length							
3 months	602	604	611	21	18	25	589	594	592	17	20	21
6 months	675	670	673	26	20	22	654	657	655	22	20	23
9 months	716	715	720	23	22	23	698	701	702	20	23	26
12 Months	755	755	761	26	23	26	739	743	742	22	26	27
18 months	825	824	825	27	25	25	804	814	811	29	30	33
					Crown Rump Length							
3 months	407	410	421	16	15	19	397	405	409	12	16	16
6 months	453	451	456	17	15	19	438	442	443	16	16	19
9 months	471	474	481	18	15	19	458	466	467	14	16	20
12 months	483	493	500	17	15	19	475	484	484	18	19	19
18 months	510	526	521	18	16	19	496	512	507	19	20	22
					Weight							
3 months	5.8	5.8	6.5	0.7	0.6	0.7	5 5	5 6	5 9	0.6	0.6	0.7
6 months	8.1	7.8	8.5	0.9	0.8	0.8	7.5	7.9	7 7	0.7	0.8	0.8
9 months	9.5	9.3	9.9	1.1	0.9	1.0	8.6	8 9	9.0	1.4	1.0	0.9
12 months	10.5	10.0	10.8	1.2	1.0	1.1	9.8	9.9	9.9	1.2	1.2	1.1
18 months	12.1	11.7	12.2	1.3	1.1	1.2	11.1	11.3	11.4	1.3	1.3	1.3

Legend: Kf : material of these studies
V S : Vickers and Stuart
S : K. Simmons

Measurements for Body Length and Crown Rump Length in millimeters.
Measurements for Weight in kilograms.

parison of the actual age of the patient with the age for which the figures of each measurement actually found in this case would be average value. In the case chosen for an example (Chart 2) the slight deficiency in body length proves to be due to short legs with an average stem length. The small head is the most significant feature. Wide chest, short and broad hands, thin calves (poor muscle development) are other characteristic features. At the bottom of these report sheets we mark down the impression which we get by the aspect of the patient with regard to types of body build according to 4 systems of classifications. The systems used are the ones described by *Sigaud, Kretschmer, Tandler,* and *Lazar*. The practical value of such classifications is not yet established. It may be mentioned, however, that the system used by *Lazar* appeared to be of some value in connection with guidance problems in the institutional care of problem children. Relation between anthropometric findings and classification of the general body build offer a wide field for further study; still more inter-

CHART 2

ANTHROPOMETRIC HABITUS ANALYSIS

Report for

Name: R. R.
Address:
Date of Birth: 11/24, 1944.
Date of Examination: 5/25, 1945.
Age: 0 years; 6 months.

	Actual Findings: cm	inches	These are average values for an age of: Years	Months	Average values for the patient's Age	Height
	(kg)	(pds)				
Body Length	64.0	25¼	—	5¼	65.5	—
Sitting Height	43.5	17	—	5½	43.8	43.0
Stem Index	68.0%		high even for newborn		66.6	66.8
Weight	6.9	15¼			7.5	7.1
Pelidisi Index	94		—	5	96	96
Circumference of Head	39.4 !	15½	—	3¼ !	42.1 !	41.5 !
Chest:						
middle position	44.0	17¼	—	7	43.0	42.0
inspirium	—	—				
exspirium	—	—				
excursion	—	—				
relative	68.7 !				66.0	66.0
Wrist	10.3	4	—	5½	10.4	10.2
Forearm	13.2	5¼	—	5½	13.5	13.1
Arm	13.3	5¼	—	5½	13.5	13.1
Calf	15.5	6⅛	—	4 !	16.8	16.2
Hand Length	7.4	2⅞	—	3½ !	7.9	7.7
Hand Breadth	4.3	1¾	—	7½	4.2	4.1
Middle Finger	3.4	1⅜	—	5	3.5	3.4
Relative Hand Length	11.6				12.1	12.2
Relative Hand Breadth	58.1 !				52.9 !	53.0 !
Relative Middle Finger	45.9				44.4	44.4

Impression about the constitutional type according to the systems of:

Sigaud:	*Kretschmer:*	*Tandler:*	*Lazar:* Boys:	Girls:
Cerebral	Leptosome	Hypertonic	Infantile	x Infantile
Respiratoric	x Eurysome	x Hypotonic	Puerile	Puerile
x Digestive	Athletic	Normotonic	Juvenile	Virginal
Muscular			Masculine	Muliebris
				Virago

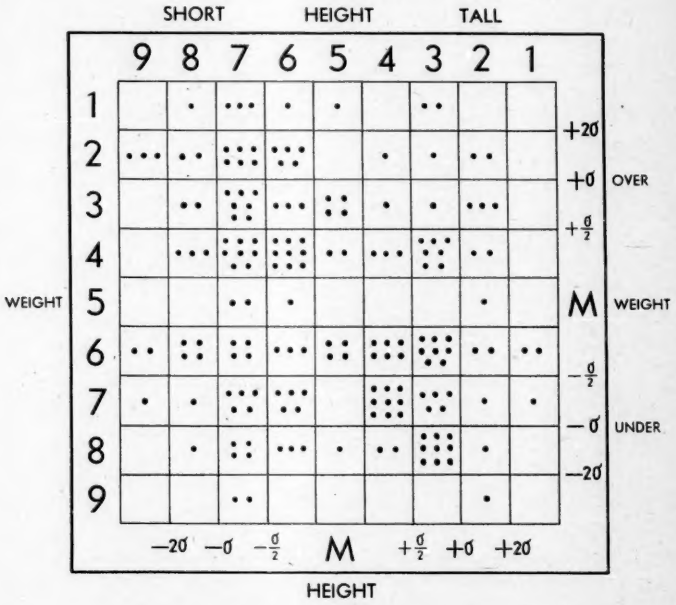
Anthropometric Diagnosis: Dysplastic Type, Microcephaly, Broad Build. (small head, wide chest, broad hand)

esting are the relations between body build types on the one hand and psychologically analyzed personality types on the other hand. It must be mentioned, however, that in cases of definite organic pathology the group-

ing according to any of the classifications mentioned above is very difficult in many cases and in some cases impossible.

To obtain a quick orientation about the type of body build in any examined child or in any group of children, different methods of graphic illustration may be used. Chart 3 shows the distribution of height and weight values, grouped according to evaluation classes, for 175 boys of 6 months of age. The weight was evaluated not according to the age but

Chart 3.

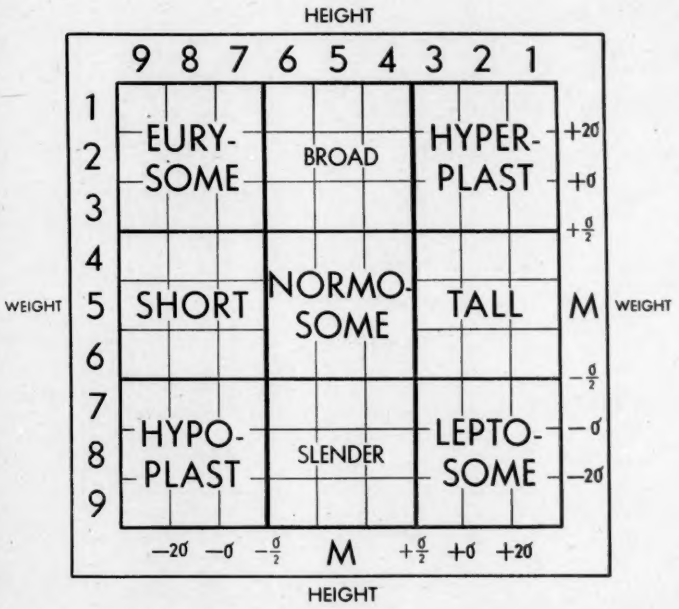


DISTRIBUTION OF HEIGHT AND WEIGHT VALUES AMONG 176 BOYS OF 6 MONTHS

according to the individual's height. By using these evaluation classes, the children of the whole group may be classified into 9 main types of body build: *Normosomatic* children with body length and weight deviating from the mean value not more than one half of the standard deviation (S. D. or σ); or children with height and weight within the evaluation classes 4-6, as defined above; *tall* and *short* children with deviations of the height for more than ½ S. D. (evaluation classes 1-3 and 7-9). but weight not deviating more than ½ S. D. (evaluation classes 4-6); *broad* and *slender* build

children with characteristic deviations of the relative weight values (classes 1-3 and 7-9), but average height (classes 4-6); *hyperplastic* and *hypoplastic* children with deviations of height and weight in the same direction, that is, tall and overweight on the one hand (classes 1-3 for height and for weight) and short and underweight on the other hand, (classes 7-9 for height and weight); finally, tall and slender children (height classes 1-3, but weight classes 7-9) as *leptosomatic,* and short and overweight children as *eurysomatic* (with height classes 7-9, but weight classes 1-3). (Chart 4.)

Chart 4.



9 Basic Types of Body Build

The same scheme may be used to follow the development of a single child over any period of time. Chart 5 shows the results of the examinations of a boy who rather persistently stayed within the limits of normosomatic features; the figures within the graph indicate the age period at the time when the examinations were done; thus the points in this graph represent the condition of this boy in the age of: newborn, 3, 6, 9, 12, 17, 21, 27, 30, 33, 36, and 48 months. As a contrast, Chart 6 shows in composite the con-

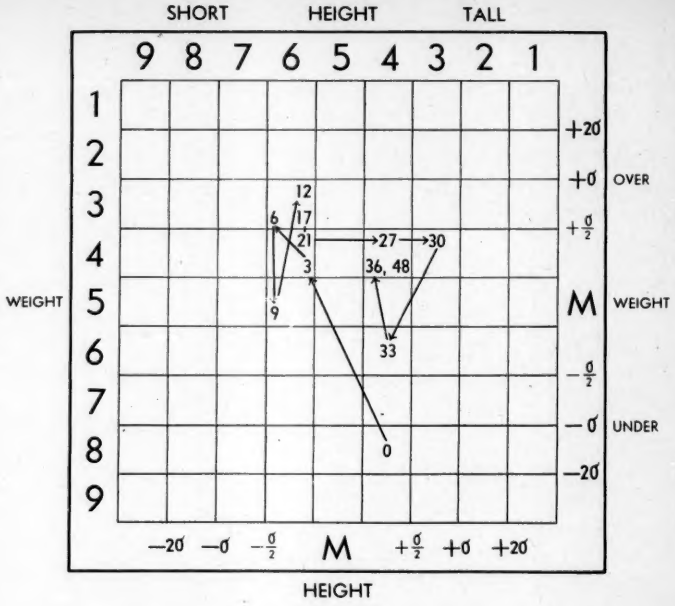


Chart 5.

Explanation of Chart 5 and 6

The figures in the graphs of these charts indicate the age in months at the time of the examinations. The location of these figures indicates the evaluation of height and weight measurements found in these examinations.

ditions of 3 boys with characteristic features of 3 different types: One boy (a) was leptosome as a newborn, later persistently hyperplastic (with 6, 12, and 18 months) or tall near hyperplastic (with 3, 24, and with 36 months); the next boy (b) was persistently broad build, with examinations in the age of newborn, 3, 6, 9, 12, 18, 24, and 36 months; the third boy (c) was always short, but changed gradually from eurysome (with 10 days, 3, 6, 9 months) to short (with 12 and 24 months) and finally to hypoplastic (with 36 and 42 months) by steadily decreasing relative weight values.

Typical changes from one type to another type may also be followed sometimes even more impressively by another method of graphic illustration as shown in Charts 7a and 7b. These charts show the course of height and weight with regard to the 9 evaluation classes again, but put into another form. Chart 7a illustrates the changes which took place in a boy who was short as a newborn; with 2, 3, 6, and 9 months about leptosome

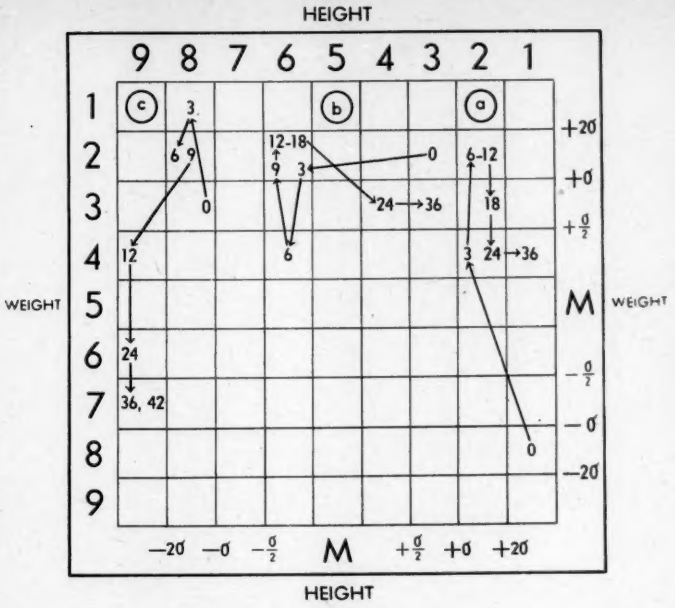


Chart 6.

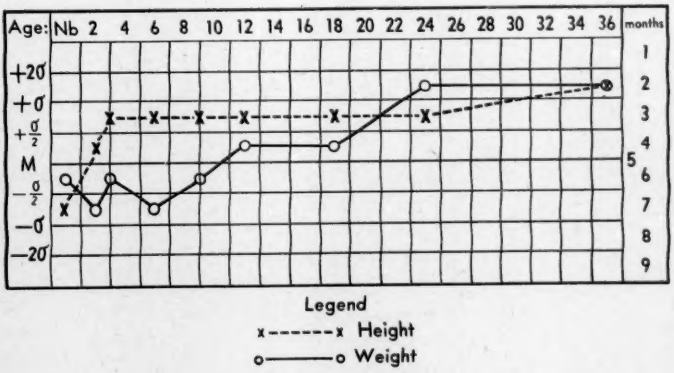


Chart 7a.

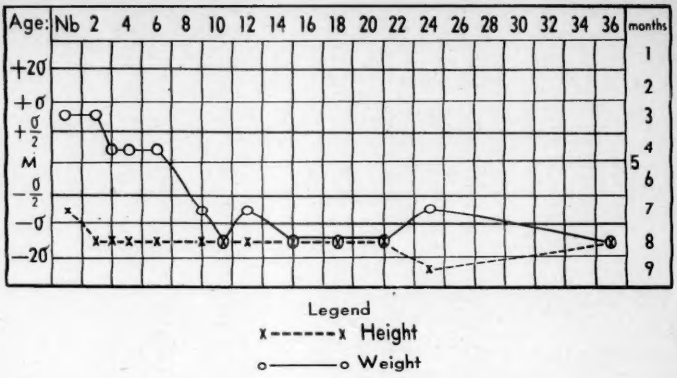
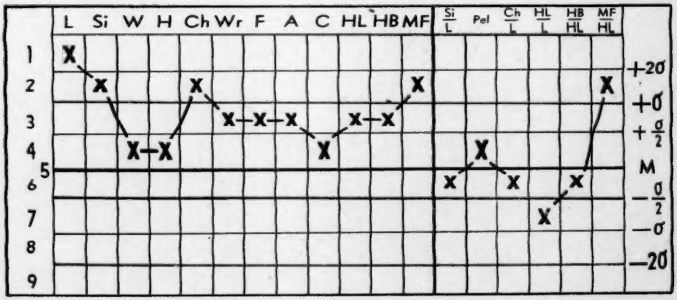


Chart 7b.

(tall and slightly underweight), then the relative weight values improved and with 12 and 18 months he would be classified as tall, until finally with 24 and 36 months, height and weight reached the higher evaluation classes; therefore characteristics of a hyperplastic type are represented in this age period. The boy in 7b was short and overweight (eurysome) as a newborn and with 2 months, short with 3, 4, and 6 months and starting with 9 months throughout the age periods of 12, 15, 18, 21, 24, and 36 months stayed short and underweight or hypoplastic.

Finally we come to the question of the analysis and utilization of the other measurements taken in these studies. To illustrate this procedure we present graphs for 3 boys of the 6 months old group. Chart 8 shows the



TALL

Chart 8.

results of the anthropometric examination in a boy with tall body, long legs, long fingers, otherwise short and narrow hand; slender calf and comparatively small head are other characteristic features. Chart 9 shows a typical eurysome boy, short and overweight with long trunk and short legs, wide chest and big broad hands. Chart 10 illustrates the findings in a hyperplastic boy with all measurements high above average, wide chest, high values for the circumference of arm, forearm and calf, average proportions of the hand. As a contrast to these "normal" cases Chart 11 shows the findings in a boy where a hypoplastic development was found in connection with a congenital heart abnormality.

The question of persistence or variation of characteristic features in body build was approached in several series of earlier studies (27-29). We tried, for instance, in a comparatively small group of children, to follow the changes in body build during the first years of life compared with the in-

Explanation of Charts 8-12

Graphs, illustrating the findings, on different individuals, for the following measurements and indices:

Measurements

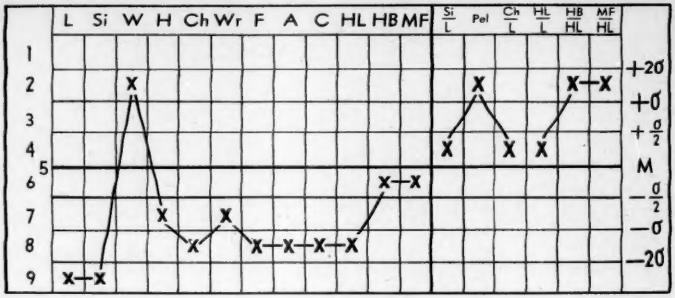
L	Body Length or Standing Height
Si	Sitting Height or stem length
W	Weight
H	Head Circumference
Ch	Chest Circumference
Wr	Circumference of Wrist
F	Circumference of Forearm
A	Circumference of Arm
C	Circumference of Calf
H L	Hand Length
H B	Hand Breadth
M F	Length of middle Finger

Indices

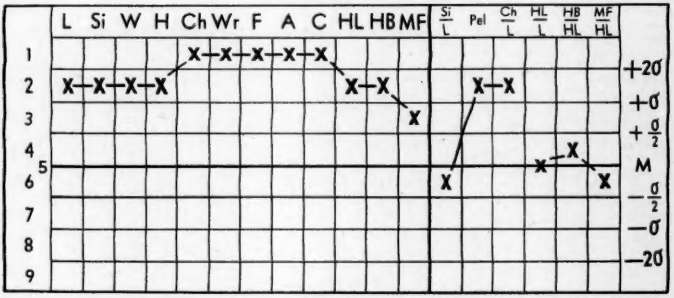
$\frac{Si}{L}$	Stem Index or Sitting Height divided by Standing Height
Pel.	*Pirquet's Pelidisi* Index (cubic root of ten times the body weight divided by sitting height)
$\frac{Ch}{L}$	Relative chest circumference or chest circumference divided by body length
H L	Relative Hand Length or hand length divided by body length
$\frac{H\ B}{H\ L}$	Relative Hand Breadth or Hand Breadth divided by Hand Length
$\frac{M\ F}{H\ L}$	Relative length of middle finger or middle finger length divided by hand length

Each value is put down as belonging into one of the following 9 evaluation classes:

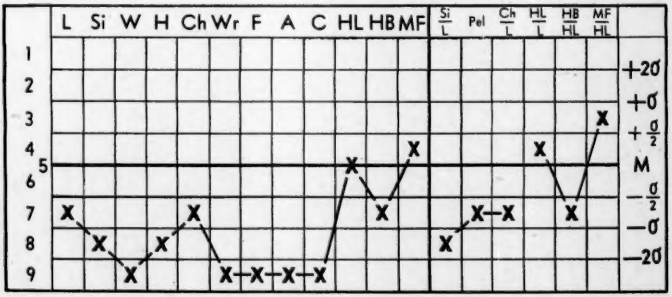
1) more than twice the standard deviation (S D or σ, Sigma) above the mean value for the age (or in case of the weight for the height.)
2) between one and two standard deviations above the mean
3) between ½ and 1 standard deviation above the mean
4) between mean and ½ above the mean
5) just the mean
6) less than ½ standard deviation below the mean
7) between ½ and 1 standard deviation below the mean
8) between 1 and 2 standard deviations below the mean
9) more than 2 standard deviations below the mean



EURYSOME
Chart 9.



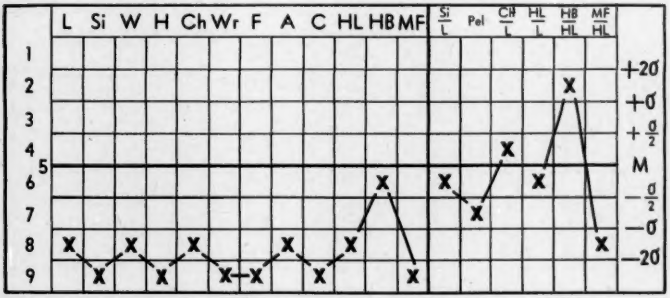
HYPERPLAST
Chart 10.



H. C. Boy, 6 months, congenital heart disease
Chart 11.

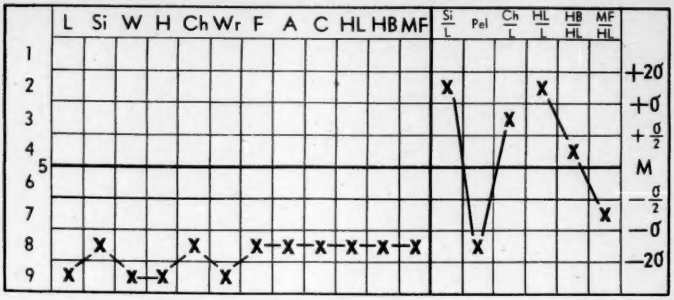
dividual's progress in ossification. In another series, we studied the occurrence of changes in the basic features of body build during the age period from 7 to 15 years on 50 children. These questions require more detailed studies, for which the methods presented here may prove to be of some help. Similar problems are now in the center of many studies conducted by various authors in this country and abroad. I have to mention in this connection the splendid work done by Howard V. Meredith on the material of the University of Iowa, and of Katherine Simmons on the material of the Brush Foundation among many valuable contributions. Chart 12 shows as an example how the comparison of anthropometric findings in different age periods is facilitated by our method of presentation. On this chart are recorded the findings in a girl, who was followed closely throughout her first 4 years of life in numerous examinations. The results of 2 of these examinations are illustrated—Chart 12a showing the findings in the age of 3 months; Chart 12b the findings on the same girl at the age of 18 months. These graphs present just 2 out of many stages during which the child always stayed within the hypoplastic type but gradually changed proportions in a way for which an increasing stem index and increasing relative hand length presented characteristic features.

The anthropometric approach in Pediatrics is still in its infancy. It has not yet grown up into a stage where practical conclusions may be drawn from our examinations. It is not yet possible to deduct specific therapeutic indications from the analysis of the physical development in individual cases, which will be one of the ultimate aims of such studies. But we believe that this approach offers some promise for the future. The intensive work done in this direction by authors like *Bakwin, Greulich, Meredith, Sontag, Stuart, Wetzel* and others in this country, by *Lederer, Viola, Szondi, Krasusky* and others abroad, has laid a sound foundation for further de-



R. S. Girl, 3 months

Chart 12a.



R. S. 18 months
Chart 12b.

velopment. We may especially expect a better insight into the connections between physical structure and personality type; a better understanding for differences in individual reactions to physical and mental strain and to disease; a better foundation for predicting the future development in normal and abnormal cases; and a better understanding for the complex nature of developmental disturbances in many abnormalities.

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GROWTH PATTERNS OF IDENTICAL TRIPLETS FROM 8 THROUGH 18 YEARS

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The program of the Fels Research Institute includes an intensive longitudinal study of the growth progress of three sets of triplets. One set, the Kramers, are 18-year-old monozygotic triplet boys, who have been followed since the age of 2 years. Various phases of their development have been reported on in earlier studies by Sontag and Nelson (11, 12), Sontag and Comstock (10), Pryor (3), Reynolds (4), and Sontag and Reynolds (13). The latter paper contains descriptions, photographs and roentgenograms of the hands of these boys.

The longitudinal study of twins and triplets offers an excellent opportunity for investigating hereditary aspects of growth patterns (Sontag, 9, p. 24). In addition, it is possible to study intensively individual variations in over-all growth curves, such as weight and height, and to relate such variations to measurements reflecting changes in the growth of the internal tissues, such as fat, muscle and bone. The present paper, describing the physical growth and development of the Kramer triplets from 8 through 18 years, has both aims.

These triplets were participants in the regular physical growth program, which includes visits to the Institute at each birthday and half-birthday. The schedule consists of medical examination, health history, anthropometric measurements, nude photographs, an extensive series of x-rays, and the recording of various stages of sexual maturation. From the available data, the following characteristics were selected for discussion:

1. General body growth:
   - Weight and height
   - Head circumference
   - Bi-iliac breadth and bi-trochanteric breadth
   - Length and breadth of the hand
2. Sexual maturation:
   - Time of appearance of secondary sex characters
   - Physicians' reports on physical development and sexual maturation
3. Skeletal and tooth development:
   - Growth in length of the radius
   - Growth in breadth of various long bones
   - Skeletal maturation
   - Eruption of permanent teeth

4. Differential tissue growth:

Growth of fat, muscle and bone in calf and forearm

Thickness of fat (skin plus subcutaneous tissue) in various parts of the body

Relation of strength of grip to tissue differentials

General Body Growth

In Figure 1, growth in standing height of the Kramer triplets, from 8 through 18 years, is shown on a Fels Composite Sheet (Sontag and Reynolds, 14, Reynolds and Sontag, 8). By this method it is possible to compare their growth progress, both with relation to each other and with relation to their positions in the Fels group of normal children. The three individual height curves are here plotted in terms of their deviations from the norms for all boys in the Fels series. Progress in weight is shown in the same way in Figure 2.

The Kramer triplets, during the decade here considered, have remained shorter in height than the average Fels boy, except during the adolescent spurt between 13 and 16 years, at which time the two larger boys exceeded

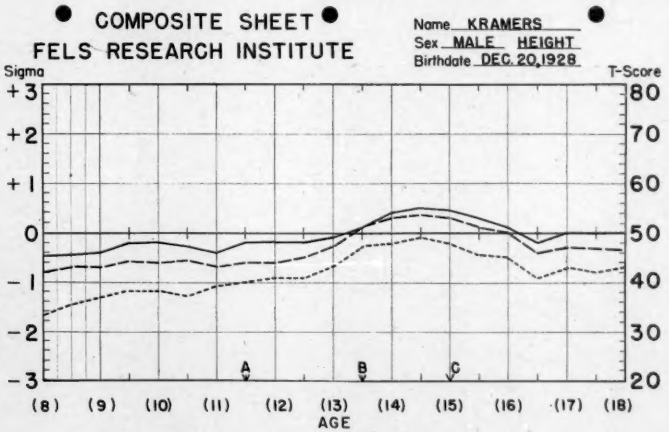

Figure 1. Growth in height from 8 through 18 years, as shown on a Fels Composite Sheet. In all figures, Fred is represented by solid line; John by long dashes; Henry by short dashes. Points A, B, and C represent ages at appearance of pubic hair, appearance of axillary hair, and appearance of hair on upper lip, respectively.

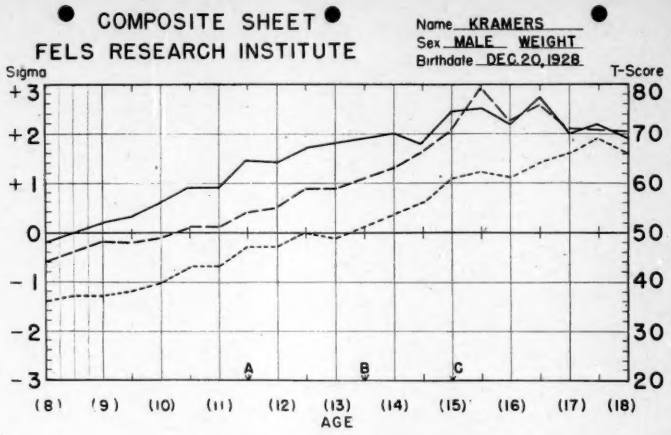

Figure 2. Growth in weight from 8 through 18 years, as shown on a Fels Composite Sheet.

slightly the Fels average. There has been a consistent trend toward an increase in height status in all three boys, amounting to about half a standard deviation over the ten-year period.

In weight, the triplets have all shown a decided upward trend, from positions below the Fels norms at 8 years to approximately two standard deviations above the average weight for 18 years. These patterns of height and weight progress have resulted, over the years, in a pronounced shift from small boys with medium body builds to post-adolescents with very stocky builds. The two larger boys, at the period of most rapid weight gain, around 16 years, were mildly obese.

There are consistent individual differences between the triplets. Fred remains tallest throughout the entire period, and Henry the shortest. Fred is also the heaviest boy, except at adolescence, and Henry the lightest. John, the middle triplet, is shorter than Fred throughout, but catches up to him in weight at 15½ years. In both weight and height, Fred and John show the more similar patterns. The tendency toward convergence in weight at 17 and 18 years is brought about by actual weight losses in Fred and John, and a continued weight gain in Henry.

Figure 3 shows the height and weight for the three boys in the more conventional form. In general, and with exceptions to be noted, Fred is the largest and most advanced boy, Henry the smallest and least advanced boy, and John steers a middle course.

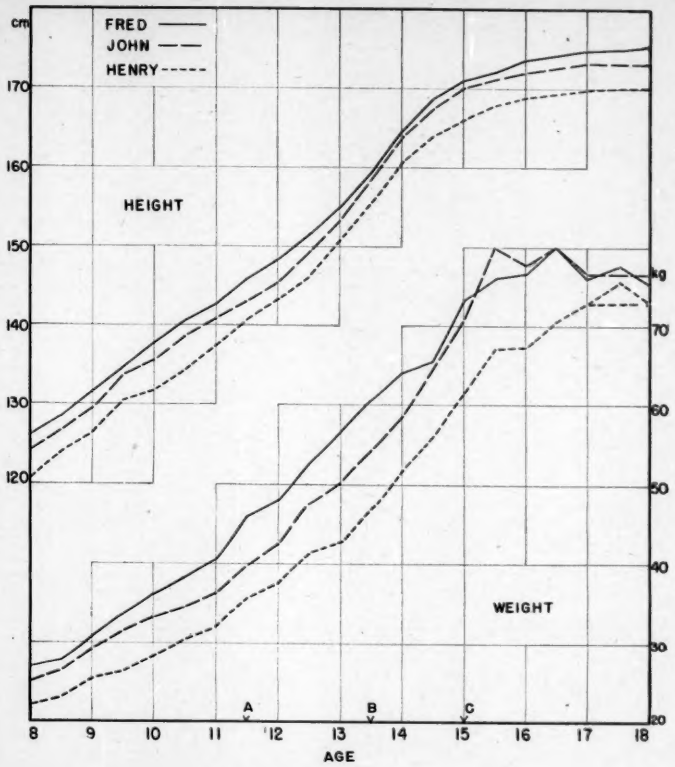

Figure 3. Growth in height and weight from 8 through 18 years, as shown on arithmetic graph.

Head circumference is plotted in Figure 4. Head circumference is taken above the level of the supra-orbitals, with moderate pressure on the tape. The values show the slow rate of increase expected at these ages. The same size differences already described are seen. Although Fred and John are the more closely associated pair in terms of size, Fred and Henry appear to be more closely parallel in their patterns of growth.

Bi-iliac diameter and bi-trochanteric diameter are also shown in Figure 4. Bi-iliac diameter is in large part a skeletal measurement, firm pressure being used to minimize the breadth of the soft parts overlying the iliac

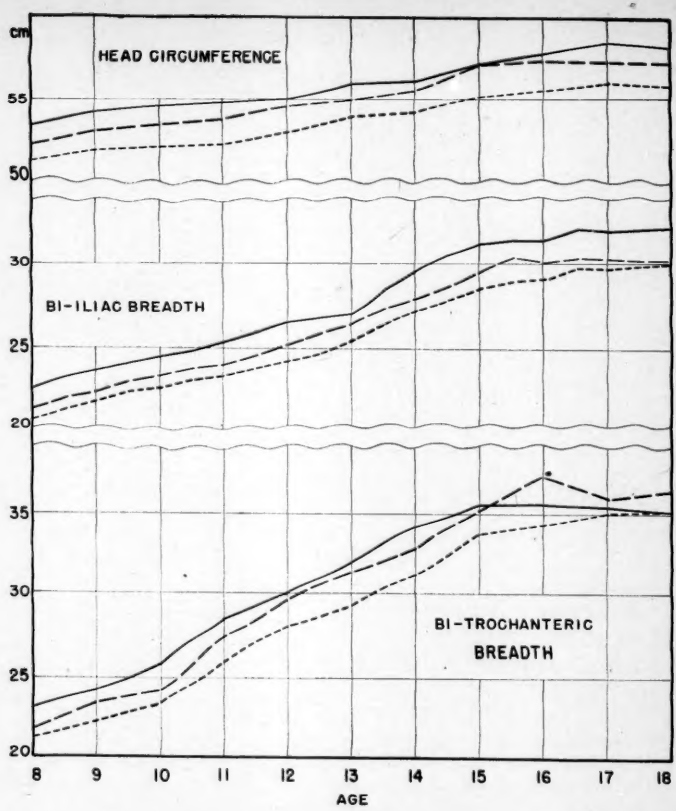

Figure 4. Head circumference, Bi-iliac breadth, and Bi-trochanteric breadth, from 8 through 18 years.

crests. The patterns shown resemble in general the picture for total height, although John, the middle-sized boy, shows a closer affinity to Henry than to Fred, the largest triplet.

Bi-trochanteric breadth, taken without pressure at the level of the greater trochanters, resembles more closely the pattern for weight. The convergence of the three boys in this measurement, and the greater size of John from 15 years on, is comparable to the picture for weight.

Figure 5 shows growth patterns for length and breadth of the osseous hand, as measured on x-ray plates taken at a 36-inch focal-film distance. "Hand length" is measured from the proximal end of metacarpal III to the

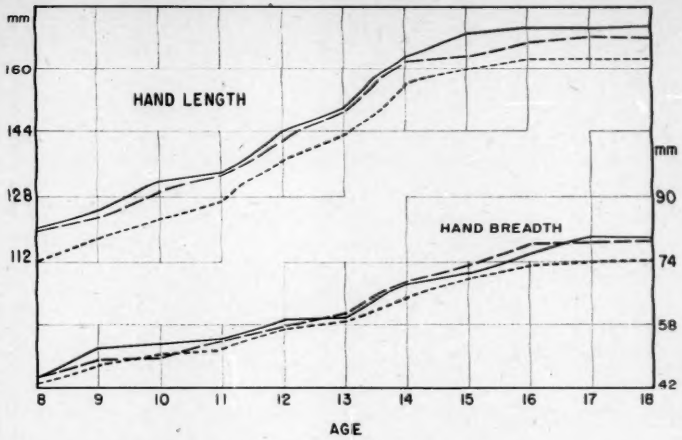

Figure 5. Length and breadth of hand from 8 through 18 years.

distal end of the distal phalanx of the third finger. The soft tissue at the tip of the finger is not included. "Hand breadth" is the sum of the breadths of the distal heads of the five metacarpals. No soft tissue is included. The usual size differences are seen in hand length; but in hand breadth, while Henry has the smallest values, Fred and John show no consistent size superiority. Both measurements show the characteristic increase in growth rates at adolescence, followed by the post-adolescent leveling off.

Sexual Maturation

In all three boys, pubic hair appeared at 11½ years, axillary hair at 13½ years, and pigmented hair on the upper lip at 15 years. Using the criteria of Greulich, *et al.*, (2), they reached maturity group 2 by 11½ years, and were in group 5 by 15 years. In spite of their maturational similarity, however, there are certain individual differences which can best be described by comments from the periodic physical examinations.

Fred:	12 years.	"Largest and least active."
	12½ years.	"Development of John and Fred practically identical, slightly advanced over Henry."
	16 years.	"Adult pubic and axillary hair."
John:	11½ years.	"In practically all respects intermediate between Fred and Henry, but closer to the former."
	12 years.	Same comment.
	13 years.	"John continues to be intermediate, but closer to Fred than Henry. Today the growth of pubic hair seemed most advanced in John."

15½ years. "The biggest of the three." (See Figure 3)

Henry: 11½ years. "The most active, lightest and shortest of the triplets. Frame not as heavy as that of his brothers. . . . Left testicle undescended."

12 years. "Has a little less pubic hair than his brothers. . . . Developed a right hydrocele after a fall."

12½ years. "Development of genitalia slightly retarded behind brothers."

13½ years. "Development of secondary sex characters now not appreciably different from John and Fred."

15 years. "The liveliest of the three."

Fred and John were circumcised at 5 years, Henry remaining uncircumcised. The hydrocele developed by Henry at 12 years remained present for over a year, and the left testicle, at 18 years, was still not palpable.

In sexual maturation, then, as in height and in most aspects of skeletal growth, Fred and John are the more similar pair, and tend to be slightly in advance of Henry. The differences are, of course, very small, and can be established only by careful examinations at periodic intervals.

Skeletal and Tooth Development

The radius was chosen as a representative long bone, and growth in length of the radius, as measured on a 36-inch focal-film x-ray, is shown in Figure 6. The pattern is very similar to that for height. In the same figure, the combined mid-shaft breadths, taken from antero-posterior x-rays of tibia, fibula, radius and ulna, are shown, and show a similar pattern.

Skeletal maturation, as seen in x-rays of the hand and wrist, was determined at each birthday, following the Flory (1) standards. The triplets showed patterns too similar for differentiation between them, except at the age of 15. After the age of 11, they were all somewhat advanced over the Flory standards:

Chronological Age	*Skeletal Age*
10	10
11	11
12	12½
13	13½
14	14½
15	(Fred, 16; Henry and John, 16¼)
16	17
17	18
18	19

In the eruption of the permanent teeth (excluding the 3rd molars), Fred was slightly advanced over his brothers, John intermediate, and Henry slightly retarded. Differences, however, were very slight, the greatest differ-

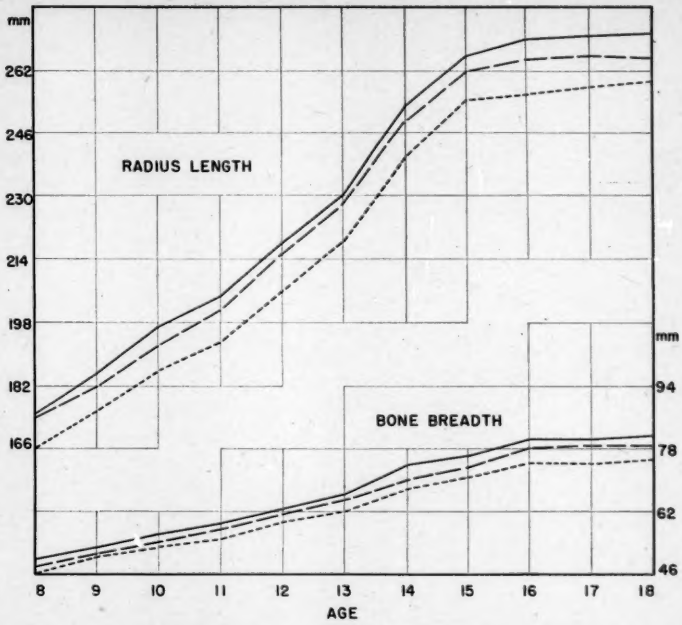

Figure 6. Radius length, and combined breadths from mid-shaft of radius, ulna, tibia and fibula, from 8 through 18 years.

ence being at 10½ years, when Fred had 20 teeth, Henry 16, and John 13. By 11, John had 26 teeth, Fred 24, and Henry 21. By 11½ years, Fred and John both had 28 teeth, and Henry 26. By 12 years, Henry also had 28 teeth. Using a crude measure of comparison, the average age at eruption of the 28 teeth was, for Fred, 9.0 years; for John ,9.1 years; for Henry, 9.2 years.

Differential Tissue Growth

The use of the x-ray offers a promising method of studying tissue differentiation in the body. Simple measurements of the breadths of bone, muscles and superficial fat in the leg and arm make possible certain comparisons of body structure which are not available from external measurements (Reynolds 5, 7).

In Figure 7, a comparison is made of the triplets in terms of a special "soft-tissue" roentgenogram of the calf. Eight such roentgenograms are taken of representative areas of the body at each half-birthday visit (Reynolds 6). Figure 7 shows the total breadth of the calf, as measured on the

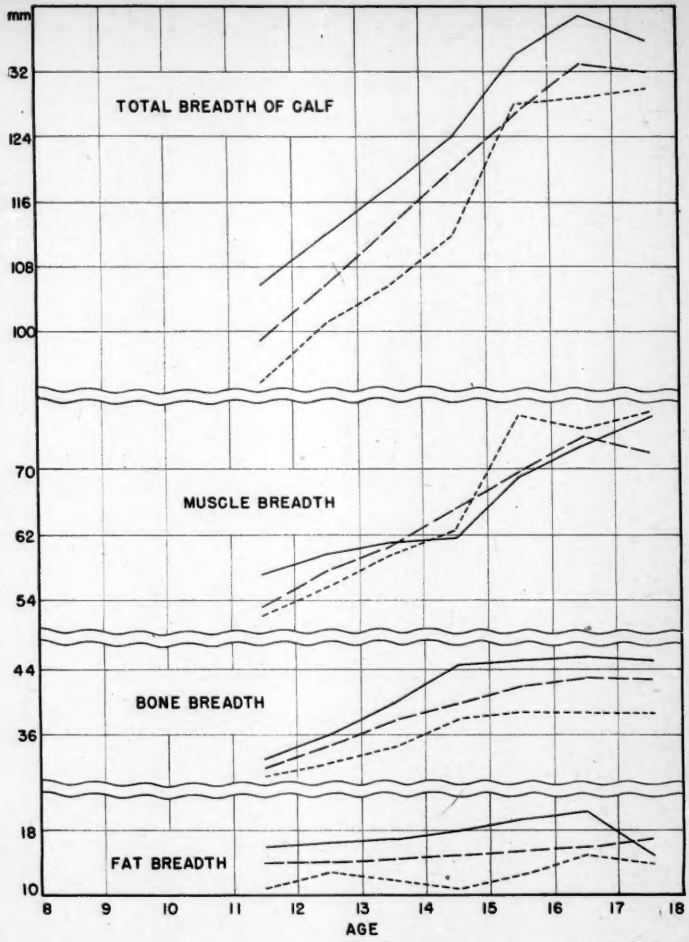

Figure 7. Total breadth of calf, and breadths of fat, muscle and bone as seen on roentgenogram, from 11½ through 17½ years.

x-ray, and the breakdown of this dimension into breadths of bone, muscle mass and superficial fat (plus skin).

Several interesting observations may be made from an inspection of this figure. The bone breadths show much the same pattern seen for other

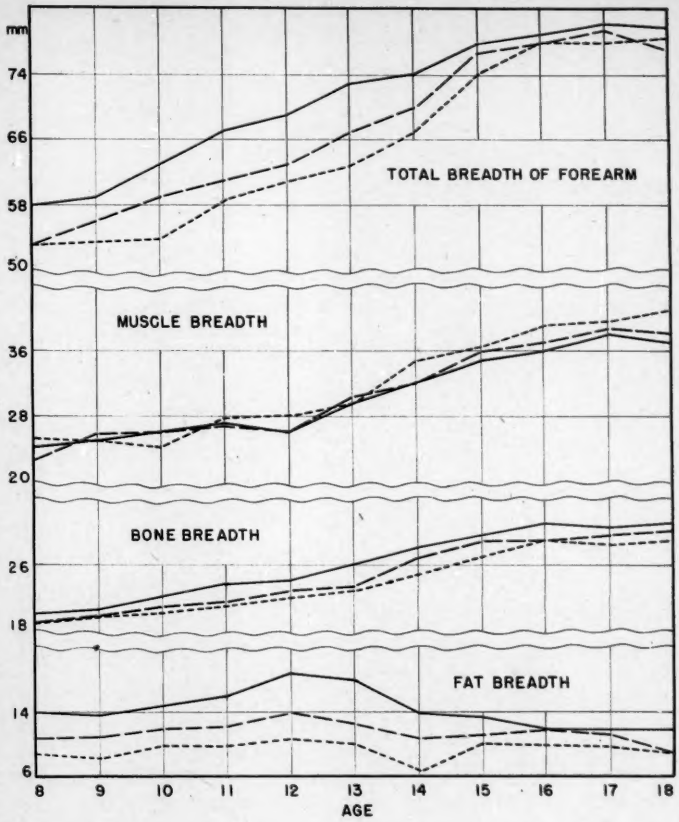

Figure 8. Total breadth of forearm, and breadths of fat, muscle and bone as seen on roentgenogram, from 8 through 18 years.

skeletal dimensions—Fred largest, John intermediate, Henry smallest. In muscle breadth, however, Henry shows a sharp increase between 14½ and 15½ years, and this rise is clearly reflected in the total breadth of the calf. In like manner, Fred's loss of superficial fat between 16½ and 17½ years shows itself in a total calf breadth which is actually smaller at 17½ years than it was a year previously. During this same period, Fred lost over 2.5 kilograms of body weight. John also shows a smaller breadth of calf at 17½ years than the year before, but his shift is related, not to fat,

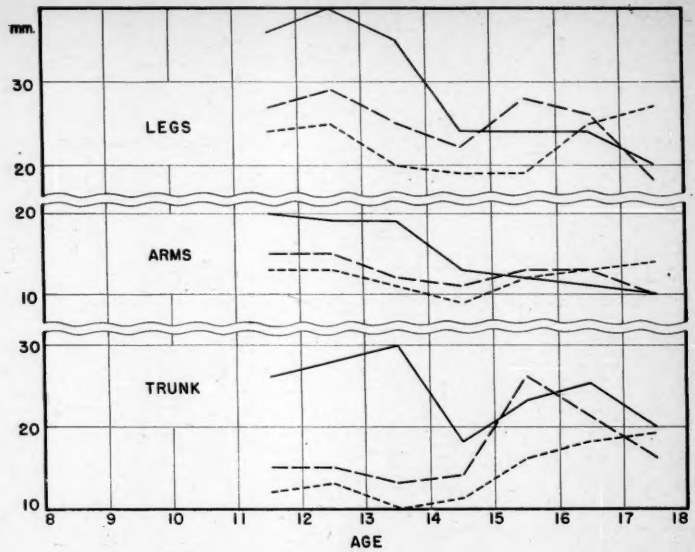

Figure 9. Breadth of superficial fat in legs (calf plus trochanter), arms (deltoid plus elbow) and trunk (waist plus chest), from 11½ through 17½ years.

but to muscle breadth, which shows a decrease. During this year, John lost 3.0 kilograms of body weight.

In Figure 8, the same type of comparison is made, for the entire ten-year period, from measurements made on x-rays of the forearm. The measurements were taken at a level 1/3 of the distance from the distal end of the radial diaphysis. Much the same relationships are seen as were shown in the calf, particularly in the greater breadth of the muscle mass in Henry, who is in external measurements the smaller triplet.

Figure 9 gives some indication of the resemblances and differences in fat distribution of the triplets. Two measurements went into the values for each area: for the legs, the breadth of the superficial fat in the calf plus the breadth of the superficial fat at the level of the great trochanter; in the arms, the fat breadth at the deltoid and at the elbow; in the trunk, the fat breadth at the waist and in the chest at the nipple level. All these measurements were taken from antero-posterior "soft-tissue" roentgenograms, at a six-foot focal-film distance. In Figure 10, the three areas are combined to give an over-all picture.

The familiar size difference may be seen for total fat breadth, between 11½ and 14½ years. Fred has considerably more fat than his brothers, who

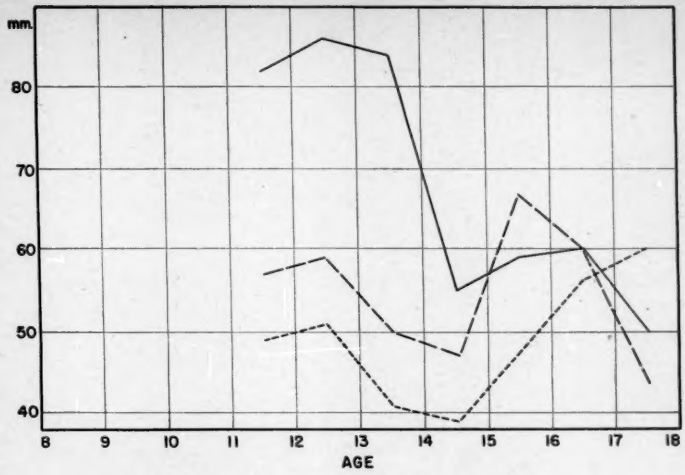

Figure 10. Total breadth of superficial fat, three regions combined, from 11½ years through 17½ years.

are in this characteristic the more similar pair. The brothers show parallel patterns during this period, all having an increase in total fat breadth between 11½ and 12½ years, and a decrease during the next two years. At 14½ years, all three boys again show an increase in total fat breadth, which is continued to 17½ years only in the case of Henry. In both Fred and John, the rise at 14½ years is followed by a subsequent loss, so that by 17½ years Henry, who has by now closely approached his brothers in body weight, has a total fat breadth which is actually greater.

In general, the same picture shown for total fat in Figure 10 may also be seen in the regional patterns shown in Figure 9. Fred's slight and temporary increase in total fat breadth is accounted for entirely by the fat growth in the trunk. For John and Henry, however, the pattern of fat breadth in all three areas is essentially similar.

It may be of some interest to relate differential tissue development and body weight to actual tests of grip strength made on the triplets at 16½ and 17½ years. The scores made by the boys on a hand dynamometer (average of three tries) are as follows:

	16½		17½	
	Right	*Left*	*Right*	*Left*
Fred (left-handed)	41	51	39	42
John (right-handed)	46	39	43	40
Henry right-handed)	41	38	40	39

At 16½ years, Fred thus had an average grip strength score of 46; John, 42.5; Henry, 39.5. At 17½, the scores were 40.5, 41.5 and 39,5, respectively.

When these values are related to body weight, in the form of an index, the triplets show the following comparisons:

	Grip strength Body weight (Kg.)	
Fred	57.4	52.3
John	53.4	54.2
Henry	56.0	52.6

Henry, therefore, the smallest of the triplets, has an absolute grip strength score which is correspondingly lower; however, when this value is equated with body weight, Henry ranks second at both age-levels, exceeding John at 16½ years and Fred at 17½ years. There appears to be some direct association between the greater muscle breadths shown by Henry at these age-levels, and the tests of grip strength.

Discussion

A consideration of the growth progress of identical triplets, using a battery of longitudinal data over an extended period of time, reveals clearly their extremely similar patterns of development. A close comparison of the individual boys reveals, in addition, an intricate shifting of relationships between variables which are themselves changing in time. If, in a study of the Kramer triplets, the only data considered were height and weight, the closer association of Fred and John would seem to be established. When, however, other factors are also brought in, no one pair seems to show consistently a more intimate association. If the boys are ranked, in accordance with either greater size of a part or earlier appearance of a characteristic, the following patterns appear:

Height: Fred, John, Henry. Fred and John more similar.

Weight: Fred, John, Henry to 15 years. Thereafter, Fred-John, Henry. At earlier age levels, a slight tendency for Fred and John to be more similar, this becoming more pronounced after 15 years. However, by 17½ years, body weight for all three boys is very close.

Head circumference: Fred, John, Henry. Although Fred and John are somewhat closer in size, Fred and Henry appear to show a more parallel development.

Bi-iliac breadth: Fred, John, Henry. Although this is a measurement with a strong skeletal component, John and Henry show more similar patterns.

Bi-trochanteric breadth: Fred, John, Henry at earlier age-levels; John, Fred, Henry after 15½ years. It is difficult to pair any two brothers.

Hand length: Fred, John, Henry. As in most skeletal measurements, Fred and John are the more similar pair, but all three patterns are very much alike.

Hand breadth: Fred-John, Henry. Fred and Henry perhaps more similar.

Appearance of secondary sex characters: No differences in time of appearance of pubic hair, axillary hair, and hair on upper lip, but small differences in maturational progress, with Fred and John more similar, and advanced over Henry, until 13½. There are some additional differences between the triplets: Fred and John are circumcised, while Henry is uncircumcised, has a left undescended testicle, and had a hydrocele at 12 years, lasting over a year.

Radius length: Fred, John, Henry. Fred and John more similar.

Bone breadths: Fred, John, Henry. Little evidence of pairing.

Eruption of 28 permanent teeth: Fred, John, Henry.

Total breadth of calf: Fred, John, Henry, with Henry rapidly approaching his brothers at the upper age-levels.

Breadth of muscle in calf: Fred, John, Henry at early age-levels, with Henry passing both brothers at 15 years.

Breadth of bone in calf: Fred, John, Henry, the usual skeletal pattern.

Breadth of fat in calf: Fred, John, Henry, except at 17½ years, when John has the larger value. There is no clear-cut pairing of brothers in any of the calf measurements, although Fred and John perhaps tend to show more similar patterns.

Total breadth of forearm, and breadths of tissues: Much the same picture as for calf.

Superficial fat: Fred, John, Henry to 14½; between 14½ and 16½, John tends to be larger; by 17½ years, Henry tends to be larger. Henry and John have more similar patterns at early age-levels, Fred and John at later age-levels. Both Fred and John have less total superficial fat at 17½ years than they had at 11½ years.

Grip strength: In absolute values, Fred, John, Henry at 16½ years; John, Fred, Henry at 17½ years. In relative values (equated to body weight), Fred, Henry, John at 16½ years; John, Henry, Fred at 17½ years.

Certain inter-relations between body weight, external body measurements, and tissue differentiation as seen in the x-ray are evident. Fred's post-puperal weight loss, reflected in a smaller calf breadth, appears to be primarily associated with a loss in fat. John's weight loss, also shown by a smaller calf breadth, seems to include, in addition to a loss of fat, a possible loss in the muscle component. Henry's continued weight gain during the upper age-levels is associated, not only with a continued growth of superficial fat, but particularly with an increase in muscle mass.

Such relations of tissue differentials to changes in dimensions and body bulk offer interesting avenues for further research. Changes in body weight

and in external dimensions gain greater significance when associated with concomitant changes in the differential patterns of tissue within the body.

SUMMARY

A longitudinal study was made of the growth progress of monozygotic triplet boys, from 8 through 18 years of age. Characteristics described include height, weight, various measures of skeletal growth and maturation, sexual development, eruption of permanent teeth, growth of the hand, certain anthropometric measurements, grip strength, and the differential growth of fat, muscle and bone in the arm and leg. Resemblances and differences in growth patterns are described and discussed, and the relation of differential tissue growth in the body to external dimensions and body weight is examined.

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APPENDIX

FRED

ITEM	*Age*— 8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Total height (cm.)	126.2	128.6	131.8	134.5	137.8	140.4	142.6	145.9	148.4	151.5	155.1
Total weight (kg.)	27.10	27.90	31.30	33.56	36.57	38.35	40.25	45.87	48.13	52.84	56.70
Head circumference (cm.)	53.2	53.7	54.0	....	54.4	....	54.6	....	55.1	....	56.1
Bi-iliac breadth (cm.)	22.3	23.0	23.5	24.1	24.5	24.8	25.2	25.8	26.4	26.7	26.9
Bi-trochanteric breadth (cm.)	23.0	23.3	24.2	....	25.8	....	28.6	....	30.0	....	32.1
Combined bone breadths (mm.)	50.0	....	52.5	....	56.0	....	59.0	....	62.5	....	66.5
Radius length (mm.)	174.5	....	184.5	....	197.0	....	204.0	....	217.5	....	230.0
Length of hand (mm.)	120.0	....	125.0	....	131.5	....	134.0	....	143.5	....	151.5
Breadth of hand (mm.)	45.0	....	51.5	....	52.5	....	54.0	....	59.5	....	60.0
Total breadth calf (mm.)	....	....	....	....	....	....	....	106.0	....	112.0	....
Breadth fat, calf (mm.)	....	....	....	....	....	....	....	16.0	....	16.5	....
Breadth muscle, calf (mm.)	....	....	....	....	....	....	....	57.0	....	59.5	....
Breadth bone, calf (mm.)	....	....	....	....	....	....	....	33.0	....	36.0	....
Total breadth forearm (mm.)	58.0	....	59.0	....	63.0	....	67.0	....	69.0	....	73.0
Breadth fat, forearm (mm.)	14.0	....	13.5	....	15.0	....	16.5	....	19.0	....	18.0
Breadth muscle, forearm (mm.)	24.0	....	25.0	....	26.0	....	27.0	....	26.0	....	29.0
Breadth bone, forearm (mm.)	20.0	....	20.5	....	22.0	....	23.5	....	24.0	....	26.0
Breadth superficial fat, arms (mm.)	....	....	....	....	....	....	....	20.0	....	19.0	....
Breadth superficial fat, legs (mm.)	....	....	....	....	....	....	....	36.0	....	39.0	....
Breadth superficial fat, trunk (mm.)	....	....	....	....	....	....	....	26.0	....	28.0	....
Total breadth superficial fat (mm.)	....	....	....	....	....	....	....	82.0	....	86.0	....
Number permanent teeth	10	10	11	12	13	20	24	28	28	....	....
Skeletal age (Flory) years	..	..	..	..	10	..	11	..	12.5	....	13.5

FRED

ITEM *Age* —	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18
Total height (cm.)	159.4	164.8	168.7	171.0	172.0	173.4	174.0	174.6	174.6	175.0
Total weight (kg.)	60.67	63.96	65.32	72.91	75.99	76.32	80.06	75.75	77.40	75.02
Head circumference (cm.)	....	56.2	....	57.1	....	57.6	....	58.4	....	58.0
Bi-iliac breadth (cm.)	28.6	29.5	30.6	31.3	31.6	31.6	32.2	32.1	32.2	32.4
Bi-trochanteric breadth (cm.)	....	34.1	....	35.6	....	35.6	....	35.4	....	35.2
Combined bone breadths (mm.)	....	74.0	....	76.0	....	80.0	....	80.0	....	81.0
Radius length (mm.)	....	251.5	....	266.0	....	270.0	....	270.5	....	271.5
Length of hand (mm.)	....	163.5	....	169.0	....	170.5	....	170.5	....	170.5
Breadth of hand (mm.)	....	68.5	....	71.0	....	76.0	....	79.0	....	79.0
Total breadth calf (mm.)	118.0	....	124.0	....	134.0	....	139.0	....	136.0	....
Breadth fat, calf (mm.)	17.0	....	18.0	....	19.5	....	20.5	....	14.5	....
Breadth muscle, calf (mm.)	61.0	....	61.5	....	69.0	....	73.0	....	76.5	....
Breadth bone, calf (mm.)	40.0	....	44.5	....	45.5	....	45.5	....	45.0	....
Total breadth forearm (mm.)	....	74.0	....	78.0	....	79.0	....	80.5	....	80.0
Breadth fat, forearm (mm.)	....	14.0	....	13.5	....	12.0	....	12.0	....	12.0
Breadth muscle, forearm (mm.)	....	32.0	....	35.0	....	36.0	....	38.0	....	37.0
Breadth bone, forearm (mm.)	....	28.0	....	29.5	....	31.0	....	30.5	....	31.0
Breadth superficial fat, arms (mm.)	19.0	....	13.0	....	12.0	....	11.0	....	10.0	....
Breadth superficial fat, legs (mm.)	35.0	....	24.0	....	24.0	....	24.0	....	20.0	....
Breadth superficial fat, trunk (mm.)	30.0	....	18.0	....	23.0	....	25.0	....	20.0	....
Total breadth superficial fat (mm.)	84.0	....	55.0	....	59.0	....	60.0	....	50.0	....
Number permanent teeth										
Skeletal age (Flory) years	....	14.5	....	16.0	....	17.0	....	18.0	....	19.0

JOHN

Item — *Age* —	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Total height (cm.)	124.4	127.0	129.7	133.5	135.5	138.5	140.7	143.1	145.6	149.2	153.5
Total weight (kg.)	25.40	26.54	29.48	31.07	33.03	34.43	36.17	39.69	42.63	47.63	50.24
Head circumference (cm.)	52.2	52.5	53.0	....	53.3	....	53.6	....	54.4	....	54.9
Bi-iliac breadth (cm.)	21.3	21.9	22.2	22.7	23.1	23.6	23.9	24.5	25.1	25.7	26.2
Bi-trochanteric breadth (cm.)	21.9	22.6	23.3	....	24.2	....	27.4	....	29.7	....	31.5
Combined bone breadths (mm.)	48.5	....	51.5	....	54.5	....	57.5	....	61.5	....	65.0
Radius length (mm.)	171.5	....	182.0	....	192.0	....	201.0	....	214.5	....	227.5
Length of hand (mm.)	119.0	....	123.5	....	129.0	....	133.0	....	142.0	....	150.0
Breadth of hand (mm.)	45.0	....	48.0	....	49.5	....	53.0	....	58.0	....	61.0
Total breadth calf (mm.)	....	....	....	....	....	....	....	99.0	....	106.0	....
Breadth fat, calf (mm.)	....	....	....	....	....	....	....	14.0	....	14.0	....
Breadth muscle, calf (mm.)	....	....	....	....	....	....	....	53.0	....	57.5	....
Breadth bone, calf (mm.)	....	....	....	....	....	....	....	32.0	....	34.5	....
Total breadth forearm (mm.)	53.0	....	56.0	....	59.0	....	61.0	....	63.0	....	67.0
Breadth fat, forearm (mm.)	11.0	....	11.0	....	12.0	....	12.5	....	14.0	....	13.0
Breadth muscle, forearm (mm.)	23.0	....	26.0	....	26.0	....	27.0	....	26.0	....	30.5
Breadth bone, forearm (mm.)	19.0	....	19.0	....	21.0	....	21.5	....	23.0	....	23.5
Breadth superficial fat, arms (mm.)	....	....	....	....	....	....	....	15.0	....	15.0	....
Breadth superficial fat, legs (mm.)	....	....	....	....	....	....	....	27.0	....	29.0	....
Breadth superficial fat, trunk (mm.)	....	....	....	....	....	....	....	15.0	....	15.0	....
Total breadth superficial fat (mm.)	....	....	....	....	....	....	....	57.0	....	59.0	....
Number permanent teeth	10	10	11	12	13	13	26	28	28	....	....
Skeletal age (Flory) years	..	..	..	..	10	..	11	..	12.5	....	13.5

JOHN

ITEM	*Age* — 13.5	14	14.5	15	15.5	16	16.5	17	17.5	18
Total height (cm.)	158.8	163.9	167.3	170.0	171.2	171.9	172.5	173.1	173.0	173.0
Total weight (kg.)	54.20	58.29	64.30	70.31	79.72	77.22	79.49	76.66	76.48	76.48
Head circumference (cm.)	....	55.7	....	57.1	....	57.4	....	57.3	....	57.2
Bi-iliac breadth (cm.)	27.3	28.0	28.7	29.4	30.4	30.0	30.4	30.3	30.2	30.2
Bi-trochanteric breadth (cm.)	....	32.8	....	35.2	....	37.1	....	35.9	....	36.4
Combined bone breadths (mm.)	....	70.5	....	73.0	....	78.0	....	78.5	....	78.5
Radius length (mm.)	....	248.5	....	262.0	....	265.5	....	266.0	....	265.5
Length of hand (mm.)	....	162.5	....	164.0	....	167.0	....	168.5	....	168.5
Breadth of hand (mm.)	....	69.0	....	73.0	....	78.0	....	78.0	....	78.5
Total breadth calf (mm.)	113.0	....	120.0	....	127.0	....	133.0	....	132.0	....
Breadth fat, calf (mm.)	14.5	....	15.0	....	15.5	....	16.0	....	17.0	....
Breadth muscle, calf (mm.)	60.5	....	65.0	....	69.5	....	74.0	....	72.0	....
Breadth bone, calf (mm.)	38.0	....	40.0	....	42.0	....	43.0	....	43.0	....
Total breadth forearm (mm.)	....	70.0	....	76.5	....	78.0	....	79.5	....	77.0
Breadth fat, forearm (mm.)	....	11.0	....	11.5	....	12.0	....	11.5	....	9.0
Breadth muscle, forearm (mm.)	....	32.0	....	36.0	....	37.0	....	38.5	....	38.0
Breadth bone, forearm (mm.)	....	27.0	....	29.0	....	29.0	....	29.5	....	30.0
Breadth superficial fat, arms (mm.)	12.0	....	11.0	....	13.0	....	13.0	....	10.0	....
Breadth superficial fat, legs (mm.)	25.0	....	22.0	....	28.0	....	26.0	....	18.0	....
Breadth superficial fat, trunk (mm.)	13.0	....	14.0	....	26.0	....	21.0	....	16.0	....
Total breadth superficial fat (mm.)	50.0	....	47.0	....	67.0	....	60.0	....	44.0	....
Number permanent teeth										
Skeletal age (Flory) years	....	14.5	....	16.3	....	17.0	....	18.0	....	19.0

HENRY

Item	Age— 8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Total height (cm.)	121.1	124.3	126.7	130.3	132.0	134.5	137.6	140.5	143.5	146.2	150.7
Total weight (kg.)	22.57	23.59	25.40	26.33	28.58	30.49	31.98	35.49	37.54	41.28	42.86
Head circumference (cm.)	51.1	51.5	51.9	....	52.1	....	52.2	....	52.9	....	53.8
Bi-iliac breadth (cm.)	20.7	21.4	21.8	22.2	22.4	22.8	23.1	23.7	24.2	24.7	25.5
Bi-trochanteric breadth (cm.)	21.4	21.8	22.4	....	23.4	....	25.9	....	28.1	....	29.4
Combined bone breadths (mm.)	46.5	....	51.0	....	52.5	....	55.0	....	58.0	....	62.0
Radius length (mm.)	166.0	....	175.5	....	186.0	....	193.0	....	205.5	....	218.5
Length of hand (mm.)	112.0	....	117.0	....	122.5	....	127.0	....	137.5	....	143.0
Breadth of hand (mm.)	43.0	....	47.5	....	50.0	....	51.0	....	57.5	....	59.0
Total breadth calf (mm.)	....	....	....	....	....	....	....	94.0	....	101.0	....
Breadth fat, calf (mm.)	....	....	....	....	....	....	....	11.0	....	13.0	....
Breadth muscle, calf (mm.)	....	....	....	....	....	....	....	52.0	....	55.5	....
Breadth bone, calf (mm.)	....	....	....	....	....	....	....	31.0	....	32.5	....
Total breadth forearm (mm.)	53.0	....	53.0	....	54.0	....	58.5	....	61.0	....	63.0
Breadth fat, forearm (mm.)	9.0	....	8.5	....	10.0	....	10.0	....	11.0	....	10.5
Breadth muscle, forearm (mm.)	25.0	....	25.0	....	24.0	....	27.5	....	28.0	....	29.5
Breadth bone, forearm (mm.)	19.0	....	19.5	....	20.0	....	21.0	....	22.0	....	23.0
Breadth superficial fat, arms (mm.)	....	....	....	....	....	....	....	13.0	....	13.0	....
Breadth superficial fat, legs (mm.)	....	....	....	....	....	....	....	24.0	....	25.0	....
Breadth superficial fat, trunk (mm.)	....	....	....	....	....	....	....	12.0	....	13.0	....
Total breadth superficial fat (mm.)	....	....	....	....	....	....	....	49.0	....	51.0	....
Number permanent teeth	10	10	11	12	12	16	21	26	28	....	....
Skeletal age (Flory) years	..	..	..	..	10	..	11	..	12.5	....	13.5

HENRY

Item	*Age* — 13.5	14	14.5	15	15.5	16	16.5	17	17.5	18
Total height (cm.)	155.5	160.4	163.8	166.0	167.8	168.7	169.3	169.9	169.8	170.2
Total weight (kg.)	46.95	51.71	56.02	61.46	66.90	67.13	70.53	72.69	75.12	72.77
Head circumference (cm.)	....	53.9	....	55.1	....	55.6	....	56.4	....	55.9
Bi-iliac breadth (cm.)	26.2	27.2	27.9	28.7	28.9	29.1	29.7	29.7	29.8	30.0
Bi-trochanteric breadth (cm.)	....	31.4	....	33.6	....	34.3	....	35.1	....	35.1
Combined bone breadths (mm.)	....	67.5	....	71.0	....	75.0	....	74.5	....	75.5
Radius length (mm.)	....	239.0	....	252.5	....	256.0	....	258.0	....	259.0
Length of hand (mm.)	....	155.5	....	159.5	....	163.0	....	163.0	....	163.0
Breadth of hand (mm.)	....	64.5	....	69.5	....	73.0	....	73.5	....	74.0
Total breadth calf (mm.)	106.0	....	112.0	....	128.0	....	129.0	....	130.0	....
Breadth fat, calf (mm.)	12.0	....	11.5	....	12.5	....	15.0	....	14.0	....
Breadth muscle, calf (mm.)	59.5	....	62.5	....	76.5	....	75.0	....	77.0	....
Breadth bone, calf (mm.)	34.5	....	38.0	....	39.0	....	39.0	....	39.0	....
Total breadth forearm (mm.)	....	67.0	....	74.0	....	78.0	....	78.0	....	79.0
Breadth fat, forearm (mm.)	....	7.0	....	10.5	....	10.0	....	10.0	....	9.0
Breadth muscle, forearm (mm.)	....	35.0	....	36.5	....	39.0	....	39.5	....	41.0
Breadth bone, forearm (mm.)	....	25.0	....	27.0	....	29.0	....	28.5	....	29.0
Breadth superficial fat, arms (mm.)	11.0	....	9.0	....	12.0	....	13.0	....	14.0	....
Breadth superficial fat, legs (mm.)	20.0	....	19.0	....	19.0	....	25.0	....	27.0	....
Breadth superficial fat, trunk (mm.)	10.0	....	11.0	....	16.0	....	18.0	....	19.0	....
Total breadth superficial fat (mm.)	41.0	....	39.0	....	47.0	....	56.0	....	60.0	....
Number permanent teeth										
Skeletal age (Flory) years	....	14.5	....	16.3	....	17.0	....	18.0	....	19.0

Contents for September

Directions for Measures and Radiographs Used in Predicting Height.
Leona M. Bayer and *Nancy Bayley* 85

Finger Painting: The Developmental Aspects.
Lucille H. Blum and *Anna Dragositz* 88

Serial Studies of Changes in Dimensions of the Dental Arches from Birth to Nine Years. *J. H. Sillman* 106

The Anthropometric Approach in the Practice of the Pediatrician.
Werner Kornfeld 113

Growth Patterns of Identical Triplets from 8 through 18 Years.
Earle L. Reynolds and *Grace Schoen* 130

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